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METHOD OF LAYING A TRIPLE LINE OF 60-IN. CAST-IRON PIPE.

By Seth M. Van Loan, Assoc. M. Am. Soc. C. E.

Articles have appeared frequently in the Engineering News relative to the work embraced under the improvement, extension and filtration of the Philadelphia water supply. These have been more or less general in substance, the different features of the great unit being handled as filters, conduits, reservoirs or pipe lines. It is a subdivision of the latter to which reference will be made in this article.

Contract No. 28, known as Lardner's Point Pipe Distribution System, embodies the placing of distributing mains to convey filtered water from Lardner's Point Pumping Station on the Delaware River to the greater part of the extensive area of the city of Philadelphia situated between the Delaware and Schuylkill Rivers. This system was designed to carry 300,000,000 gallons of water daily and 60-in. cast-iron mains were selected for the service at the head end of distribution. When different makers of cast-iron pipe were consulted relative to the casting of 60-in. pipe some question was raised as to the advisability of attempting to cast this size of a quality to meet the requirements of the specifications, from which the following paragraphs are quoted:

Par. 9.—The pipes shall be straight with concentric inner and outer surfaces. The seat or shoulder of the bell and the end of the spigot must be smooth and even, and at right angles to the axis of the pipe. . . . Sixty (60) inch pipe shall not show an eccentricity in excess of one-eighth (⅛) inch at either bell or spigot end.

Par. 10.—The thickness of the metal of the pipes and special castings will be tested by calipers. . . . Sixty (60) inch pipe and special castings shall not show upon measurement more than one-eighth (⅛) inch less thickness than is required by the specifications and drawings.

The metal in castings was required to develop a tensile strength of 22,500 lbs. upon an inch square section and a breaking load of 2,280 lbs. upon a 24-inch span. Finished pipe were to pass a hydrostatic test at foundry of 300 lbs. per sq. in. for a period of 10 minutes.

Cast-iron pipe was desirable, but designs for riveted steel pipe were produced on the contract drawings and specifications drawn in case conditions were not favorable to cast-iron. About 25,000 tons of pipe were required for this contract, or about 8½ miles of single line; as placed under construction three parallel mains were laid for 13,918 lin. ft. and four parallel mains for 784 lin. ft. The order for tonnage was divided among three different foundries, namely, Camden, Burlington and Scottdale.

A single 12-ft. length weighs upon an average 13,860 lbs., and to handle these units speedily and safely, a special traveling steam crane was provided. This machine was found invaluable, and up to the present time or for a period of 1½ years no accident has occurred while handling pipe. The placing of pipe after lowering it into the trench was done entirely by hand, a force of six men rolling the pipe to a convenient location where a second force of twelve men placed it upon a turntable and swung the piece to parallel the trench from which position it was forced by bars and seated into place. The three or four lines advanced simultaneously.

VIEW OF TRIPLE LINE OF 60-IN. CAST-IRON PIPE FOR FILTERED WATER DISTRIBUTION FROM TORRESDALE FILTERS, PHILADELPHIA, PA.

After several lengths had been made up upon the different lines, inspection showed a considerable irregularity in the registering of joints upon the inside surface of the main. Invariably the diameter of the spigot end of a pipe would be, to a noticeable degree, less than the diameter of the adjacent bell. As is usual, the making up of the joints was inspected from the outside and the following mention from the specification observed:

Paragraph 7: The space for lead joint in sixty (60) inch pipe and special castings shall not be less than nine-sixteenths (9-16) of an inch, nor more than eleven-sixteenths (11-16) of an inch. . . . Any pipe or special casting which is defective in space for lead joint whether in consequence of eccentricity of form or otherwise will be rejected.

In spite of careful centering of pipes the inside surface presented this awkward offset varying to a degree at the different quarters of the joint. It was concluded to measure four diameters of each pipe, two at right angles at both ends of piece before placing in trench. This work was done and the result proved that the different foundries developed distinctive differences. Such being the case, it was decided to match pipe for the work, entering usually the pieces from a foundry continuously. As may be expected, this caused considerable complaint from the contractor upon the work, as he was forced to sort pipe from several hundred as placed on the ground upon receipt from the foundries. This scheme was followed and a deviation from general methods, as centering pipe from the inside, was also tried.

An inspector was placed inside of the line and gave instructions to the workmen on the outside to wedge the pipe one way or another until the extremities of adjacent pieces presented concentric circles. The former plan of matching pipe worked out its own remedy as the foundries seemed to be able to cast pieces nearer to the standard. The inspector has continued his work upon the inside of the pipe and results at the present time are highly satisfactory. In order to effect a smooth surface at joints the thickness of lead is not ignored but a uniform thickness is not insisted upon providing the specifications as noted above, are met. The joint is under inspection until the jute gasket is in position. Prior to this work of matching pipe and centering from inside, certain sections of lines lacked the smoothness of bore at joints, in consequence of which men were placed inside of pipe to chip down the offsets. This was a tedious task, and it was a relief when such work was accomplished.

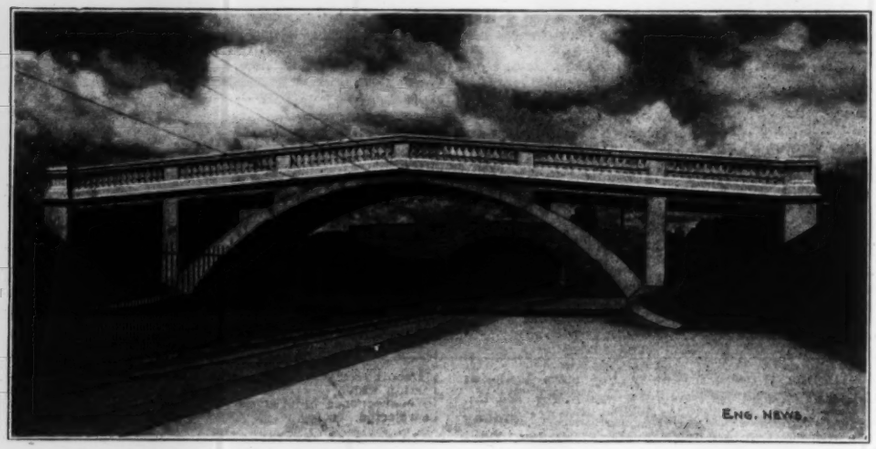
Another point under construction to which attention is called, is referred to in the specifications under Par. 115:

Whenever a length of pipe requires cutting to fit in the line it shall be done with a machine which will have a smooth end at right angles to the axis of the bore. (No cutting with chisel and hammer will be allowed.)

A brief mention of this machine might be in order. The demand for a 60-in. pipe cutting machine is so limited that none was available on the

market. In consequence, the contractors ordered such a machine, together with a similar design for a 48-in. bore. R. P. Morris, of Philadelphia, made both, the pattern being similar to the pipe-cutting machines for smaller bores. A heavy steel frame centered and securely held against the pipe by strong clamps on each quarter; a pinion set through web at the top of frame to drive a circular rack to which are fastened two cutting chisels set at opposite sides of ring, the chisels being self fed by the aid of a lug coming in contact with the screw clamp holding the chisel. Both machines were driven by steam. A clean, smooth cut was the result, and to this cut a coat of paint was immediately applied. Treating pipe by this means afforded a close joint in laying and permitted the cutting of pieces of ¼-in. minimum length, as tried upon work. Short cuts of about 6 ins. in length were convenient to place inside of sleeves when making closures so as to leave no opening between ends of jointed sections.

Active work is in progress at the present date. When a convenient length of line is completed the work is subjected to the field test, when a hydrostatic pressure of 200 lbs. per sq. in. is applied for a period of five hours. About 15,000 tons of straight pipe have been placed and tested upon the work and not one defective pipe has been discovered. The work is under the supervision of Mr. John W. Hill, Chief Engineer of the Bureau of Filtration, and is being installed by Messrs. Harmer & Quinn, general contractors, Philadelphia.



REINFORCED CONCRETE BRIDGES OVER STREET RAILWAY TRACKS, AT COMO PARK, ST. PAUL, MINN.

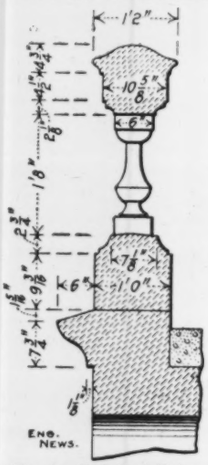


Fig. 1. Detail of Balustrade and Cornices, Como Park Foot-Bridge.

A REINFORCED CONCRETE FOOT-BRIDGE AT COMO PARK, ST. PAUL, MINN.

The accompanying illustration shows two examples of reinforced concrete arch bridge construction, one of which is a foot bridge deserving of notice because of some of the methods employed in its construction. Both bridges are Melan arches. The one shown in the background is for highway traffic and is of the usual solid spandrel construction and is finished with a cut-stone facing. Its span is comparatively short, being only 38 ft. The footbridge shown in the foreground has a span of 50 ft. and has open spandrels formed by a slab floor carried by skewback piers and the center portion of the arch ring. There is also an approach girder span at each end formed by slabs spanning spaces between the skewback piers and the abutments. The main dimensions of the bridge are as follows:

Length c. to c. of abutments	83 ft.	
Clear span of arch	50 ft.	
Crown thickness of ring	....	10 ins.
Skewback thickness of ring	2 ft.	6 ins.
Rise of arch	12 ft.	6 ins.
Width of arch ring	17 ft.	2 ins.
Width of roadway	15 ft.	
Clear span of spandrel openings	12 ft.	
Approach spans c. to c. supports	14 ft.	6 ins.
Thickness of skewback piers	2 ft.	
Thickness of abutments	3 ft.	

The reinforcement of the bridge consists of five latticed Melan ribs in the arch ring and of Thacher bars in the skewback piers and floor slabs. In the floor slabs ¾-in. bars parallel to the bridge axis are placed 7½ ins. apart on the tension side. The bars in the piers are of the same diameter and have the same spacing, but are set vertically and on both sides of the pier. The bridge was built of 1-2-4 concrete with a 1-2 mortar facing on all exposed surfaces. An important feature of the bridge is the cornice molding of the floor slab and its surmounting balustrade. This detail is clearly shown by the drawing, Fig. 1.

In constructing the bridge the balusters, posts and hand-rails were cast separately or in sections and were set in place like cut stone; the other parts of the bridge were molded in place in suitable forms. The drawings of Fig. 2 show the centers and forms that were used, and these call for no further description in respect to their main structural features. A detail that calls for special notice, however, is the plaster lath lining of the forms at all places where the finished concrete would be exposed to view. The lining, Fig. 3, shows the nature of this lining and also the form for the cornice molding of the edge of the floor slab. Briefly the forms were lined with patent wood laths, consisting of boards with parallel dove-tail grooves and ribs, which were plastered with a coat of cement mortar and finished smooth. This lining cost 55 cts. per square foot, but it gave an excellent surface finish to the facing mortar of the concrete work. It was used on all exposed surfaces, including the soffit of the arch ring. Before laying the concrete the plaster lining was coated with boiled linseed oil; this unguent was chosen as the best after experimenting with various other oils and mixtures.

The abutments of the arch were each cast in place in one day. One day was required to build each of the end abutments and each of the skewback piers as high as the floor slab. The two slab spans with their matched edges on each side of the bridge were concreted in one day. This completed the concreting to the base of the balustrade and this was completed in one day. The balusters were cast in zinc molds and the posts and the sections were cast in cast iron molds. In molding the balustrade no particular difficulty was encountered except in the case of the balusters, where considerable trouble was experienced in filling the forms principally on account of air pockets. The method was finally adopted of filling the forms as full as possible and then driving a ¾-in. round rod through the center. This rod aided in filling all parts of the mold and also added strength to the baluster. The molds for balusters were all made in two parts, which proved to be a mistake. They should have been made in three parts for the round parts of the baluster and in two parts for the square parts.

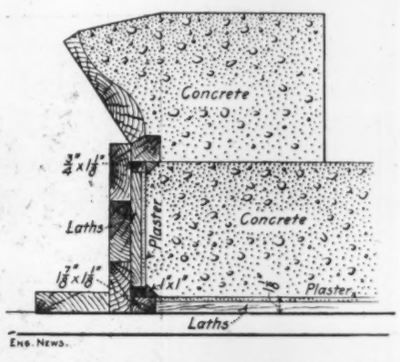


Fig. 3. Detail of Cornice Form and Lath and Plaster Form Lining, Como Park Foot-Bridge.

Both of the bridges illustrated in the general view were built by William S. Hewett & Co., of Minneapolis, Minn., for the Twin City Rapid Transit Co., of which Mr. George L. Wilson is Chief Engineer. We are indebted to the contractors and the engineer for the material from which this description has been prepared.

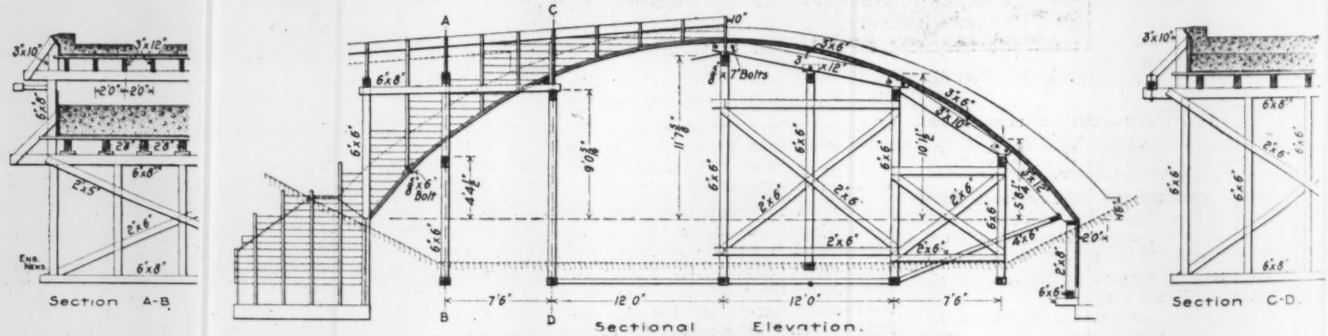


FIG. 2. CENTERS AND FORMS FOR COMO PARK FOOT-BRIDGE.

A NEW SYSTEM OF GARBAGE COLLECTION.

Many of our readers will remember the crusade which was waged by sanitarians a dozen years or more ago against the old-time wooden garbage carts. It was pointed out that to clean any such cart at the garbage dump was practically impossible, and that its passage through the streets was little short of a public nuisance. The sanitarians demanded the abolition of these antique and malodorous vehicles and the substitution of metal carts with covers.

No one could deny the justice of the indictment which the sanitarians brought against the old wooden carts; and so, in cities which desired to be progressive, the change was made; and progress has halted at that point ever since. But if any one considers the metal garbage cart now in use a success, the circumstantial evidence is strong that that person is stone deaf and has his olfactory nerve paralyzed.

Seriously, if anybody but the sanitary experts who know what is best for us, had set such an infernal instrument of torture as the modern sheet-metal garbage cart rumbling over city pave-

A MODEL SYSTEM OF GARBAGE COLLECTION, OAKLAND, CAL.

ments at an hour when most city dwellers are trying to sleep, we believe the populace would have risen en masse in their wrath. Of all the hideous sounds that vex the nerves of the city dweller, we can recall nothing nearly so bad as the garbage cart rumbling over a stone block pavement. It is little short of a peripatetic boiler shop.

Then, too, notwithstanding the fact that the sanitarians were the ones who recommended the metal cart, it would require a fine distinction in odors to tell wherein it smells less vile than the vehicle which it displaced. The load which it carries is the same, and although the cover is of some advantage after the cart is loaded, it matters little while the cart is making its collecting rounds and the cover is lifted at every doorway.

The fact is, moreover, that the whole matter of successful garbage *disposal* (and by this we mean a success which will satisfy the public) hinges to a far greater extent than is often realized on the method of collection. So long as garbage carts emit rank smells and an unearthly noise, so long will the residents of any quarter where a garbage disposal plant is located, and along all streets leading to it, rise in wrath and appeal to the courts.

With this preface we wish to call the attention of our readers to what appears to us to be far and away the most important improvement in garbage collection—and disposal—that has been made for many years. The accompanying illustration comes pretty near telling the whole story. The wagon here shown carries fifty 10-gallon garbage cans, each of which weighs when filled about 50 lbs. The cans are separated from each other by rubber buffers and are locked in position by rubber clamps, and the wagon itself has rubber tires. Such a vehicle passes through the streets with almost no noise, and when garbage collection is done in the early morning hours, this is a matter of no small importance.

Further than this, the wagon and its contents emit no odor even in collecting. Each can has a tight cover *which is only removed at the place of final disposal.* There the cans, after emptying, are all washed and sterilized and on the return trip, an empty clean can is left in place of each full one taken away.

Contrast this with the ordinary system of garbage collection where each household's garbage can is merely emptied into the dump cart and put back uncleaned. In nine households out of ten, it is safe to say, the garbage can is not washed after emptying, and the result is, of course, that the putrid can renders putrid everything that is put into it. The result is that no matter how frequently garbage is collected, it is offensive stuff, and difficult to transport and handle anywhere without creating a nuisance.

But with a clean sterilized can furnished the householder at each garbage collection, it ought to be possible to collect garbage before it becomes offensive, and, what is of even greater importance from a financial point of view, it should be also possible *to decrease the frequency of collections.*

It is not so much the disposal of a certain number of tons of garbage that costs money. The collection of these tons in small lots from a hundred or a thousand separate households is what takes the time of workmen and teams. Now if by furnishing a clean can to the householder each time, it becomes possible to make the rounds less frequently, it is well worth while carting the cans themselves to the garbage dump and back again.

The chief objection which will be made to this system, doubtless, is that the cans will be taken away when only part full. One householder will have a can full when the neighbor next door has only a trifle in his can. This difficulty can be met, however, by having householders set out cans only when filled at least three-fourths full, under the penalty that if they set out a can with only a small amount in it, the collectors will empty the can into another and will not leave a clean one in its place. We should judge that with a little organization and experience it would soon be feasible to have the cans come to the place of final disposal at least three-fourths full. As to the objection that the weight of the empty cans has to be hauled back and forth, it is doubtful whether in the wagon illustrated there is any more dead weight in proportion to the pounds of garbage carried than there is in the ordinary steel garbage cart in use in New York City.

The system of garbage collection above described has been in use for the past two years in the city of Oakland, Cal. It was installed by the Dixon Garbage Crematory Co., of Toledo, O., which controls the manufacture of the wagon illustrated. The inventor of the system is Mr. E. J. Little, Secretary and Treasurer of the company.

EVAPORATION OBSERVATIONS IN THE UNITED STATES.*

By Herbert Harvey Kimball.†

It is important that irrigation engineers should know not only the rainfall, but also the evaporation over any given region. Unfortunately, the measurement of evaporation presents many more difficulties than the measurement of precipitation. In fact, the rate of evaporation from land surfaces depends upon so many different elements that it can be treated only in the most general manner. Thus, it has been shown that the evaporation from saturated soil covered with growing plants is greater than from water surface, but becomes less when the level of complete saturation falls a few inches below the soil surface, and continually diminishes as this level recedes to increasing depths. Also, the evaporation from a forest of evergreen trees is greater than from a forest of leafy trees; from the latter it is greater than from grass, from which in turn it is greater than from bare soil. The composition of the soil has its effect upon the rate of evaporation, and so also has the state of cultivation. Furthermore, the rate of evaporation from any surface has been found to vary with its temperature, with the quantity of moisture in the air, and with the wind velocity.

Even if we were able to determine the exact relation between each of these elements and evaporation, we see at once how hopeless it would be to undertake to compute accurately the evaporation over any very extended region of land surface. It is therefore customary to deduct the run-off from the rainfall over a watershed, and to attribute the difference to evaporation. This has been done by Mr. George W. Rafter in "Water Supply and Irrigation Papers No. 80, U. S. Geological Survey," for twelve drainage basins in the eastern part of the United States, as follows:

Drainage basins.	Years of Record.	Rainfall.	Run-off.	Evaporation.
		in.	in.	in.
1. Muskingum River, Ohio..	1888-1895	39.7	13.1	26.6
2. Genesee River, N. Y.....	1890-1898	40.3	14.2	26.1
3. Croton River, N. Y.....	1877-1899	49.4	22.8	26.6
4. Lake Cochituate, Mass....	1883-1900	47.1	20.3	26.8
5. Sunbury River, Mass.....	1875-1900	46.1	22.6	23.5
6. Mystic Lake, Mass.....	1878-1895	44.1	20.0	24.1
7. Neshaminy Creek, Pa.....	1884-1899	47.6	23.1	24.5
8. Perkiomen Creek, Pa.....	1884-1899	48.0	23.6	24.4
9. Tohickon Creek, Pa.....	1884-1898	50.1	28.4	21.7
10. Hudson River, N. Y.....	1888-1901	44.2	23.3	20.9
11. Pequannock River Conn..	1891-1899	44.2	26.8	20.0
12. Connecticut River, Conn..	1872-1885	43.0	22.0	21.0

The rainfall and run-off have been computed for many other watersheds in the United States, particularly in California, where the run-off is a much smaller percentage of the rainfall than in the Eastern States.

As a practical problem in irrigation, however, the evaporation from water surfaces is of much more importance than the evaporation from land surfaces. The engineer will naturally determine his water supply, not from the annual precipitation, but from the run-off of available streams. Having ascertained this, the question of losses becomes important, and if storage basins are of considerabe area the loss by evaporation in a dry climate becomes very serious, having been estimated, in some cases, to be as much as 30 to 50% of the amount stored.

Fortunately, the determination of the evaporation from a water surface presents fewer difficulties than the evaporation from land surfaces. Generally speaking, the determination may be made by two quite different methods; (1) by direct measurements from properly exposed water surfaces, and (2) by computations based upon the temperature of the water surface and the value of certain meteorological elements. With proper attention to exposure, direct measurements of evaporation from water surfaces should give the more reliable results. Unfortunately, proper exposure is not always practicable, and it is therefore necessary to consider the character of the exposure in connection with each series of evaporation experiments, and in some cases to apply a correction before the results will fairly represent the evaporation from a reservoir or a lake.

One of the most exhaustive series of evaporation experiments in the United States was conducted by Mr. Desmond Fitzgerald,‡ between the years 1876 and 1886, in connection with the reservoirs of the Boston waterworks. He not only measured the evaporation directly by means of tanks floating on the surface of reservoirs, some of them arranged to record automatically the rate of evaporation, but he also conducted elaborate experiments to determine the relation between the rate of evaporation and the temperature of the water surface, the temperature of the air, the amount of moisture in the air, and the movement of the air.

He found that the rate of evaporation depended upon three elements; the vapor pressure corresponding to the temperature of the surface of the water, the vapor pressure corresponding to the dew-point of the atmosphere, and the velocity of the wind.

*A paper read before the Twelfth National Irrigation Congress at El Paso, Tex., November 16-18, 1904.

†Librarian, U. S. Weather Bureau, Washington, D. C.

‡Transactions of the American Society of Civil Engineers, vol. 15, p. 581.

Representing by E the evaporation in inches per hour from a water surface, by e_s the vapor pressure in inches corresponding to the surface temperature of the water, by e_d the vapor pressure corresponding to the dew-point of the atmosphere, and by v the wind velocity in miles per hour, he obtained:

$$E = 0.0166\ (e_s - e_d)\left(1 + \frac{v}{2}\right)$$

as the equation for the hourly rate of evaporation. This equation he found to hold good for an ice surface as well as for a water surface, in the shade as well as in the sunshine, and by night as well as by day.

Measurements of evaporation from the water in a tank three feet cube, the top flush with the surface of the ground, have been made since 1887 at Fort Collins, Colo.,* under the direction of Prof. L. G. Carpenter. The temperature of the water in the tank was found to be lower than the temperature of the water in reservoirs and lakes in the vicinity, and in consequence the evaporation was less. Fitzgerald† notes a like deficiency in temperature and evaporation in connection with tanks set in the ground near Croton Reservoir, N. Y., but at Lakeport and Kingsbury Bridge, Cal., the temperature and the evaporation, as measured in a tank set in the ground, were found to exceed like measurements in tanks floating in lakes. Since a great many measurements of evaporation have been made from tanks set in the ground, it is important that these discrepancies in water temperature and evaporation be borne in mind.

From his investigations in 1889 Professor Carpenter found that the daily evaporation could be very accurately expressed by the equation:

$$E = 0.3868\ (e_s - e_d)\ (1 + 0.0025\ W),$$

where W represents the wind movement in twenty-four hours, the other symbols having the same significance as in Fitzgerald's equation. Reduced to a like period (twenty-four hours), the latter becomes:

$$E = 0.3984\ (e_s - e_d)\ (1 + 0.0208\ W).$$

The agreement between the two is quite remarkable when we consider the difference in the climatic conditions at the two stations. The difference in the values of the coefficient of W was attributed by Professor Carpenter to the fact that Fitzgerald measured the wind velocity at the surface of the water, while Carpenter's wind velocities were obtained from an anemometer on the roof of the college building.

*See Annual Report of the Agricultural Experiment Station, Fort Collins, Colo.

†Proceedings of the American Society of Civil Engineers, vol. 15, p. 617.

Subsequent observations served to confirm the accuracy of Carpenter's formula, and after ten years, by means of comparative readings between his standard tank and tanks floated on water surfaces, he computed the average annual evaporation from a free water surface at Fort Collins to be 59.5 inches instead of 46.3 inches, as he had measured it.

In 1887 and 1888 Prof. T. Russell,* of the U. S. Signal Service, investigated the rate of evaporation in standard thermometer shelters, by means of observations with Piche evaporimeters. This instrument, as is well known, consists of a glass tube about nine inches long and 0.4 inch internal diameter, hermetically sealed at the top. Over the bottom is placed a disk of porous paper, which is held in position by a copper disk pressed against the open end of the tube by a suitable spring attachment. Capillary action keeps the paper moist. Its exposed area is known, and the amount of evaporation is determined by means of a scale etched on the side of the tube.

To determine the relation between the rate of evaporation from a Piche evaporimeter and a water surface Professor Russell exposed two of the Piche instruments in a closed room in which were two open tin dishes filled with water. Both the Piche evaporimeters and the dishes were weighed at frequent intervals, and it was found that the Piche instruments evaporated 1.33 times as fast as the open dishes. Eighteen Piche instruments were then exposed at various Signal Service stations, from May 31 to September 30, 1888, and the observed quantity of evaporation was divided by 1.33 to reduce it to the evaporation from a water surface. By the method of least squares, the relation between the rate of evaporation, the temperature of the evaporating surface, and the amount of moisture in the air was determined from observations made during the month of June. The temperature of the evaporating surface in this case was the same as that of the wet-bulb thermometer. The monthly rate of evaporation was found to be quite accurately expressed by the equation:

$$E = 30\left[\frac{43.88\ (e_w - e_d) + 1.96\ e_w}{B}\right]$$

in which e_w is the vapor pressure in inches corresponding to the monthly mean temperature of the wet-bulb thermometer, e_d is the vapor pressure corresponding to the monthly mean dew-point of the atmosphere, and B the monthly mean barometric pressure in inches. By means of this formula Professor Russell computed the monthly evaporation at 140 Signal Service stations from July, 1887, to June, 1888, inclusive, using the monthly mean wet-bulb and dew-point temperatures derived from tri-daily observations. From the data thus computed [illegible] accompanying chart showing "Lines of equal annual depth of evaporation in inches from free water surface" was prepared. Professor Russell states his belief that [illegible] chart represents approximately the evaporation that takes place from the surfaces of ponds, rivers, reservoirs, and lakes in the vicinity of Signal Service stations, basing his belief principally upon the results of evaporation experiments conducted under the direction of the Russian Physical Observatory at St. Petersburg, from May to October, 1875, and discussed by Ed. Stelling in Bassin [illegible] No. 3, of Wild's Repertorium für Meteorologie. [illegible] Stelling's equation, however, is:

$$E = A\ (e_s - e_d)\ (1 - Bv)$$

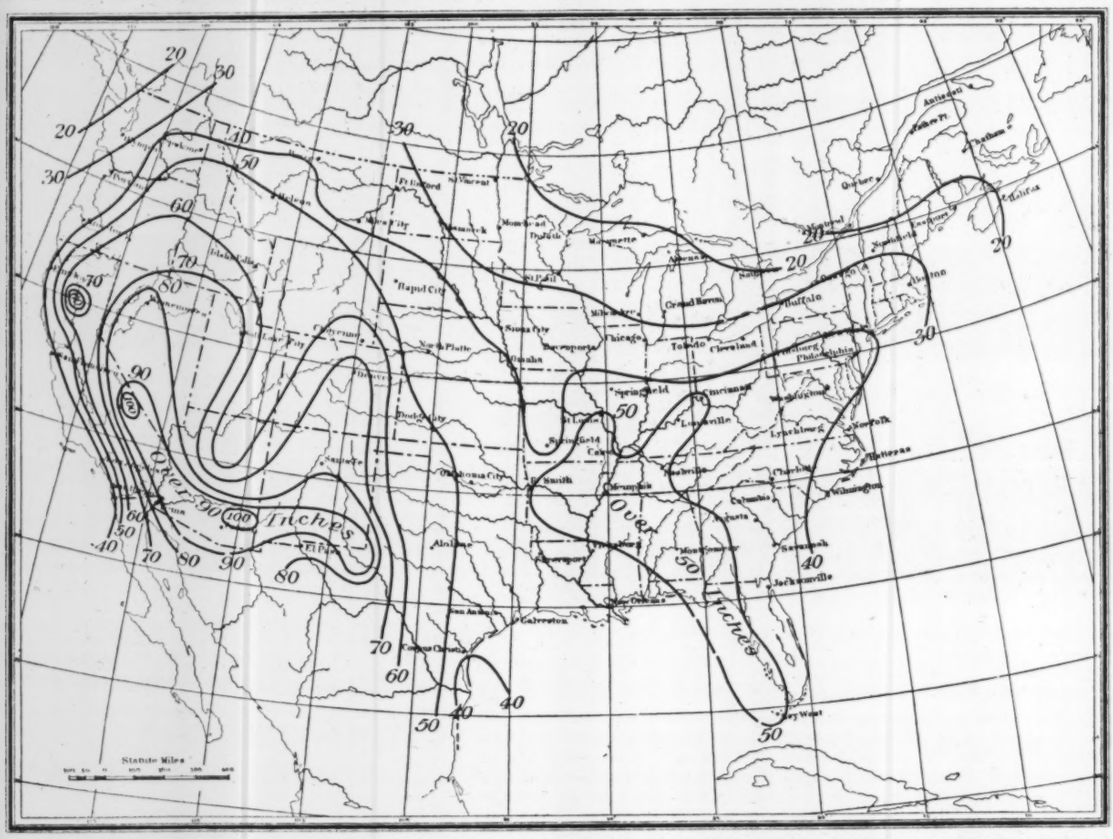
which is identical in form with Fitzgerald's, the [illegible] having the same significance. The values of E, A, and B in Stelling's equation are computed for the centigrade system, and vary with the seasons. They are therefore not easily comparable with Fitzgerald's values.

Russell's formula, however, departs radically from those of Fitzgerald, Carpenter, and Stelling, in that it substitutes the vapor pressure corresponding to the temperature of the wet-bulb thermometer for the vapor pressure corresponding to the temperature of the surface of the water, and adds a term depending upon this same vapor pressure, e_w, in place of the wind velocity term. This latter is dropped, and the equation represents the evaporation with a wind velocity outside the shelter of 7.1 miles per hour, which was the average at the stations where the Piche observations were being made, during June, 1887.

It is evident that this wind velocity will not apply to all parts of the United States for all seasons of the year. Neither will it do to substitute the temperature of the wet-bulb thermometer for the temperature of the water surface, the former being cooler than the latter. No doubt the additive term containing e compensates for this in a measure, but we must conclude that Russell's formula does not rest upon as sound a physical basis as do the formulas of Stelling, Fitzgerald, and Carpenter. The term $\frac{1}{B}$ was introduced on account of the wide variations in the value of B at the different stations. It is unimportant when discussing the observations at a single station.

Upon the organization of the Irrigation Survey by the U. S. Geological Survey in 1888, arrangements were made for measuring the evaporation at several points in the arid regions of the United States. It was recognized that the rate of evaporation depended upon the dryness of the air, the temperature of the water surface, and the velocity of the wind at the water surface. An effort was therefore made to measure the evaporation from a water surface having the same temperature as the surface of lakes or reservoirs, and exposed to the same wind velocity. To accomplish this galvanized-iron evaporating pans, three feet square and eighteen inches deep, were floated on the surface of the body of water from which the evaporation was to be measured. The pans were kept nearly full, with the surface of the water in them about on a level with the water outside. The evaporation was at first measured by some sort of gage, but later was determined from the amount of water that was added to bring the surface to the top of a pin projecting from the center of the pan. A record of the water temperature inside and outside the pans was kept. Usually a difference was noted, the inside temperature being higher in the daytime and lower at night. The average is, however, about the same in each. It is not probable that the water in pans is exposed to quite so high a wind velocity as the average over outside surfaces, but to offset this the water in the pans wets the sides, and this increases the evaporating surface. It is therefore assumed that in general the evaporation from a floating pan of this type when kept nearly full represents the evaporation from the outside water surface very closely.

Several of the agricultural experiment stations measure the evaporation from pans, but most of the pans are set



LINES OF EQUAL ANNUAL DEPTH OF EVAPORATION IN INCHES FROM A FREE WATER SURFACE, COMPUTED FROM METEOROLOGICAL OBSERVATIONS FROM JULY, 1887, TO JUNE, 1888.

*Monthly Weather Review, 1888, p. 235.

in the ground, and for reasons already given their indications are not believed to represent the evaporation from reservoirs and lakes as closely as do those from floating pans.

For the purpose of checking Russell's computed values, Table I has been prepared. In the first two columns are the names of stations and the evaporation computed by Russell. In the following columns are the names of neighboring stations at which measurements of evaporation from water surfaces have been made, the amount of evaporation measured, and the character of the exposure. We are thus enabled to judge of the probable value of Russell's chart.

The results given in Table I. are not strictly comparable, since the stations are not in all cases identical, and in some cases, especially in California, the reservoirs are at a greater height than the Weather Bureau stations, and in consequence the water surfaces are correspondingly colder. Generally speaking, Russell's results appear to be the higher.

Since Russell's equation was deduced from tridaily observations, it is not applicable to the present 8 a. m. and 8 p. m. observations of the Weather Bureau unless one first applies a correction to the mean of these two observations to reduce it to the mean derived from tridaily observations. The equations of Fitzgerald and Carpenter appear to have a quite general application, provided we know the temperature of the water surface, the dew-point, and the wind velocity. It would seem, therefore, that in the absence of reliable measurements of evaporation from water surfaces, an effort should be made to determine the temperature of water surfaces near Weather Bureau stations, and where the evaporation is measured from tanks sunk in the ground the relation between the temperature of this evaporating surface and the temperature of lakes or reservoirs in the vicinity should be carefully determined.

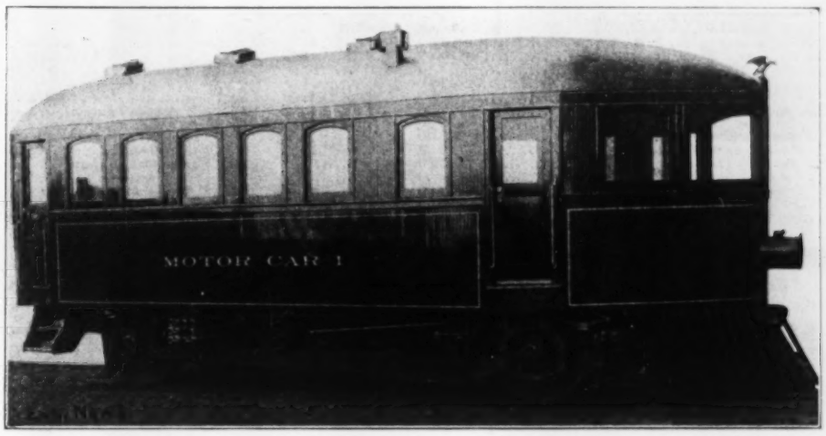
Seasonal evaporation naturally varies with geographical position. Some of its peculiarities are shown in Table II.

Several series of evaporation measurements that do not cover the winter season have not been referred to in this paper. While they are of value, the above table indicates the importance to irrigation engineers of making the readings throughout the entire year.

GASOLINE MOTOR CAR: UNION PACIFIC RY.

The Union Pacific Ry. has recently completed a motor car for local passenger service at Portland, Ore. It is mounted on two axles, one of which is driven by a gasoline engine of a class intended for motor boats, but redesigned and built to the railway company's plans by the Standard Motor Construction Co., of Jersey City, N. J. The engine has six cylinders 6 × 8 ins., and is 6 ft. long, 2 ft. 3 ins. wide and 4 ft. 7 ins. high, weighing 3,000 lbs. It is rated by the railway at 100 HP., but the builders state that it is capable of developing 150 HP. In the design of the clutches and controlling mechanism, simplicity has been one special aim. The car is quickly put in motion with the assistance of air pressure and a starting device, and the speed then picked up by the gasoline engine without jar. The acceleration is said to be very rapid. Air is stored in large reservoirs under the car.

The car is 31 ft. long, and has a long pointed head end and a turtle-back roof, for the purpose of reducing the air resistance at high speeds. At the rear end is a vestibuled platform, and the rear end is rounded off to reduce the vacuum produced by cars with square end. The rear doors and the traps over the steps are operated by pneumatic cylinders and controlled from the front cab. Projecting through the roof are Cottier exhaust ventilators and fresh-air inlets, the air being heated in winter by being passed over hot pipes before entering the car. In winter, also, the warm circulating water from the cylinder jackets is led around the sides of the car; but in summer this water is piped to coils beneath the floor. More or less of the water can be sent to the interior pipes according to the weather. The car is lighted by acetylene gas and has an acetylene headlight. It has seating capacity for 25 passengers, and is operated by one or two men. The wheels are 3 ft. 6 ins. diameter, with a wheel base of 16 ft. 6 ins., but the spring arrangement is specially designed to give an easy motion and to prevent any pitching action of the car. Horseshoe yokes resting on the boxes have spiral springs seated between their lower ends and the truck frames, while at each end are elliptical plate springs between the truck frame and the car body.



GASOLINE MOTOR CAR FOR LOCAL SERVICE: UNION PACIFIC RY.

The car was designed and built at the railway company's shops at Omaha, Neb., under the direction of Mr. W. R. McKeen, Jr., Superintendent of Motive Power and Machinery of the Union Pacific Ry.

A METHOD OF COMPUTING FLOOD DISCHARGE AND CROSS-SECTION AREA OF STREAMS.

By E. C. Murphy,* M. Am. Soc. C. E.

The proper size of channel cross-section of a stream depends mainly on the rate of flow of the stream. The method proposed in this paper for finding cross-section area is based on the fundamental formula that $A = \frac{Q}{V}$, where A is the cross-section area of the stream, Q the maximum discharge in cubic feet per second, and V is the velocity of the maximum discharge in the channel.

The formulæ in common use for this purpose generally have the form, $A = C M^k$ in which A is the cross-section area in square feet, M is the drainage area in square miles or acres, C is a quantity whose value depends on the character of the country, and k is a fraction generally less than unity, e. g., the formula used by the engineers of the Mo. Pac. Ry. Co. is $A = 0.25 M$ to $0.17 M$. The proposed method is based on measurements of the flood flow of streams on the observed maximum range of stage and slope of each particular stream.

The maximum discharge of a stream depends on several quantities. Primarily it is dependent on,

1. Extent, duration and intensity of precipitation, especially the latter in the case of small drainage basins.

2. Direction of motion of the storm causing the flood. If the storm moves in the direction of flow of the stream, the intensity of flood will be greater than if it moves in the opposite direction or across it.

3. On the amount of snow on the ground and the temperature during the storm. Large floods are often due largely to melting snow when the ground is frozen, and in such cases the run-off is much larger than the rain fall.

4. On the storage, both natural and artificial, in the drainage basin. Storage spreads the flood over a larger period and thus reduces the maximum rate of flow.

4. On the physiography of the drainage basin. The maximum rate of flow from a comparatively long and narrow drainage basin with tributaries entering at a considerable distance apart, will be less than from a basin of nearly circular shape of the same size but with the tributaries entering the main stream not far apart. Steep impervious deforested slopes of drainage basin, steep slope of bed of tributaries, and small slope of main stream intensifies flood flow.

6. Among the quantities that intensify the flow, and are more or less artificial, may be mentioned controlled storage in basin; deforestation and cultivation; reduction in width of stream by placing abutments of bridges in the stream; the use of piers that prevent scour of bed, collect drift and hold back a part of the flow for a time, causing a greatly increased flood wave; the formation of ice gorges and the failure of dams and reservoir walls.

Freshets occur on all streams usually once a year, sometimes two or more times a year; great floods that result from natural causes occur at irregular intervals, varying from a few years to many years apart. It is impossible to predict the time of their occurrence or determine whether the largest recorded flood is the largest that will ever occur.

It is very difficult to measure the discharge of a stream at maximum stage with accuracy. At such a time the stream usually carries much drift, overflows its banks and changes its stage rapidly, all of which make accurate measurement of flow difficult.

It may be seen from the foregoing and other facts that might be cited that the rate of flood discharge of streams in different drainage basins

*Engineer, U. S. Geological Survey, Washington, D. C.

Table I.—Annual Evaporation.

Russell's Formula. Stations.	Evaporation. Inches.	Surface Measurements. Stations.	Evaporation. Inches.	Exposure.
Boston, Mass.	34.4	Boston, Mass.	34.78	Beacon Hill Reservoir.
New York, N. Y.	40.6	Boston, Mass.	39.11	Chestnut Hill Reservoir, floating pan.
Cheyenne, Wyo.	76.5	New York, N. Y.	39.64	Croton Reservoir, floating pan.
		Laramie, Wyo.	46.80	Ground.
		Fort Collins, Colo.	46.16	Ground.
El Paso, Tex.	82.0	Fort Collins, Colo.	59.50	Computed for reservoir.
		Fort Bliss, Tex.	82.65	Floating pan.
Salt Lake City, Utah.	74.4	Fort Douglas, Utah	42.46	Floating pan.
Fort Grant, Ariz.	101.2	Tucson, Ariz.	75.78	
Prescott, Ariz.	56.0	Tempe, Ariz.	65.00	Floating pan.
Sacramento, Cal.	54.3	Clear Lake, Cal.	32.38	Floating pan.
		Clear Lake, Cal.	33.40	Ground.
Fresno, Cal.	65.8	Kingsbury Bridge, Cal.	47.79	Floating pan.
		Kingsbury Bridge, Cal.	59.49	Ground.
Los Angeles, Cal.	37.2	Arrowhead Reservoir	86.60	Ground. (Elev. 5,160 ft.)
San Diego, Cal.	37.5	Sweetwater Reservoir	57.55	Floating pan.

Table II. Evaporation in inches.

Month.	Boston, Mass.	Fort Collins, Colo.	Clear Lake, Cal.	Fort Bliss, Tex.
January	0.90	1.50	0.85	2.35
February	1.20	2.00	0.60	2.45
March	1.80	3.50	2.00	6.25
April	3.10	5.00	2.82	7.35
May	4.61	6.50	3.85	10.85
June	5.86	8.00	4.30	11.20
July	6.28	9.50	5.90	9.60
August	5.49	8.50	4.70	9.50
September	4.09	6.50	3.72	9.20
October	2.95	4.50	2.12	6.80
November	1.63	2.50	0.65	4.15
December	1.20	1.50	0.85	2.95
Year	39.11	59.50	32.28	82.65

Table I.—Maximum Rate of Flow of Streams in Cubic Feet per Second per Square Mile.

Stream and Place.	Drainage Area. Sq. Miles	Date.	Max. Rate.	Authority.
1... Starch Factory Creek, New Hartford, N. Y....	3.4	Mar. 25, 1904	109.6	R. E. Horton.
2....Skinner Creek, Mannsville, N. Y.....	6.4	1891	124.2	U. S. B. Engrs., D. W., 1899.
3....Croton River, South Branch, N. Y.	7.8	1869	73.9	Trans. Am. Soc. C. E., Vol. 25.
4....Stony Brook, Boston, Mass.....	12.7	.....	121.0	Rept. Stony Brook Flood Com.
5....Beaver Dam Creek, Altoona, N. Y.....	20.7	.....	111.0	U. S. B. Engrs., D. W., 1899.
6....Sawkill Creek, near mouth, N. J	35.0	.....	228.6	W. S. P., No. 35.
7....Flat River, R. I.....	61.0	March, 1843	120.0	Trans. Am. Soc. C. E., Vol. 4.
8....Nine Mile Creek, Stittville, N. Y.....	62.6	August, 1898	124.9	U. S. B. Engrs., D. W., 1899.
9....Rock Creek, Washington, D. C.....	77.5	.....	126.0	Tech. Ory. Mass. Inst., 1891.
10....Hockanum, Conn.....	79.0	.....	78.1	Rept. U. S. Ch. of Engrs., 1878.
11....Nashua River, Mass.....	84.5	1850	71.0	Trans. Am. Soc. C. E., Vol. 4.
12....Deer River, Deer River, Mass.....	101.0	April, 1869	78.1	U. S. B. Engrs., D. W., 1899.
13....Tohickon Creek, Mt. Pleasant, Pa.....	102.0	1885	112.5	Rept. Phila. Water Board.
14....Ramapo River, Mahwah, N. J.....	118.0	1903	105.1	Computed.
15....Neshameny Creek, B. So. Fks., Pa.....	139.0	1894	97.6	Eng. News, May 1, 1893.
16....Perkiomen Creek, Frederick, Pa.....	152.0	1889	69.2	Rept. Phila. Water Board.
17....Croton River, Croton Dam, N. Y.....	339.0	.....	74.9	Trans. Am. Soc. C. E., Vol. 4.
18....Stony Creek, Johnstown, Pa.....	428.0	.....	70.0	J. J. R. Croes.
19....Raritan River, Bound Brook, N. J.....	879.0	1882	59.3	N. J. Geol. Sur., 1894, Pt. 4.
20....Genesaee River, Mt. Morris, N. Y.....	1070.0	1894	39.2	Twentieth Annual, U. S. G. S.
21....Chemung River, Elmira, N. Y.....	2055.0	June 1, 1889	67.1	City Report, 1889.
22....Mohawk River, Rexford, N. Y.....	3384.0	1892	23.1	Rept. U. S. B. Engrs., D. W., 1899.
23....Kennebec, Waterville, Me.....	4410.0	1896	25.2	Nineteenth Annual, U. S. G. S.
24....Merrimac, Lawrence, Mass.....	4553.0	.....	23.4	Nineteenth Annual, U. S. G. S.
25....Potomac Dam No. 5, Md.....	4640.0	.....	22.2	N. J. Geol. Sur., 1894, Pt. 4.
26....Delaware, Lambertville, N. J.....	6500.0	.....	53.8	Trans. Am. Soc. C. E., Vol. 10.
27....Delaware, Stockton, N. J.....	6790.0	1841	37.5	N. J. Geol. Survey, 1894, Part 3.
28....Connecticut, Holyoke, Mass.....	8660.0	May, 1854	21.1	Rept. U. S. Ch. of Engrs., 1878.
29....Connecticut, Hartford, Conn.....	10234.0	.....	20.3	Trans. Am. Soc. C. E., Vol. 7.
30....Potomac River, Md.....	11043.0	.....	42.6	Eng. News, May 25, 1893.

will differ by a considerable amount. The difficulty of measuring the rate of flow of any flood is so great however, and the uncertainty of any flood being the greatest that will occur on that stream is so great that it is useless to attempt to figure closely the maximum rate of flow. It will suffice, therefore to divide the country into six or eight parts, according to the topography and rainfall, and to obtain a relation between rate of flow and size of drainage basin for each.

Table I. gives the maximum rate of flow from drainage basins in the northeastern part of the United States, the drainage area in square miles above the point of measurement, and the maximum rate of flow from them. Some of these results were obtained from careful weir measurements, others are rough estimates.

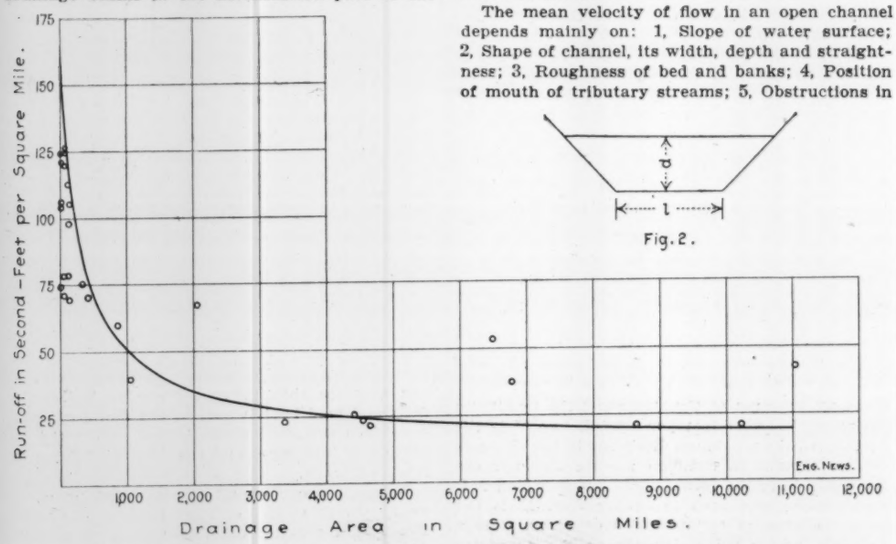


FIG. 1. CURVE ILLUSTRATING THE RELATION BETWEEN AREA OF DRAINAGE BASIN AND MAXIMUM RATE OF FLOOD FLOW FROM IT PER UNIT OF AREA.

These data are plotted in Fig. 1, using area of drainage basin in square miles as abscissæ and maximum rate of flow as ordinates. Four of these, viz., Nos. 21, 26, 27 and 30, are so much larger than any of the others of the same size of drainage basin that the writer questions their reliability and has not given weight to them. The curve A B, whose equation is

$$q = \frac{46790}{M + 320} + 15$$

has been drawn to represent the relation between rate of flow and size of drainage basin for this section of the country. In this equation, M is the drainage area in square miles, and q is the maximum discharged in cubic feet per second per square mile of drainage.

Table II. has been prepared from this equation, and gives the maximum rate of flow per square mile from drainage basins of various sizes in the northeastern part of the United States. Knowing the size of drainage basin at a given place on a stream in this section of the country, the maximum discharge is found by multiplying the drainage area in square miles by the proper value found in Table II.

The mean velocity of flow in an open channel depends mainly on: 1, Slope of water surface; 2, Shape of channel, its width, depth and straightness; 3, Roughness of bed and banks; 4, Position of mouth of tributary streams; 5, Obstructions in the channel, such as ice gorges, dams of logs, drift, boulders, etc.

Fig. 2.

The formula in general use of computing the discharge of a stream is

$$Q = AV = AC\sqrt{RS} \quad \ldots\ldots (1)$$

In this formula, Q = discharge in cubic feet per second; A = area of waterway in sec. ft.; V = mean velocity in feet per second; S = the slope of the surface, R = the hydraulic radius $= \frac{A}{P}$ where P is the wetted perimeter and

$$C = \frac{a + \frac{b}{n} + \frac{c}{S}}{1 + \left(a + \frac{c}{S}\right)\frac{n}{\sqrt{R}}}$$

a, b and c are constants and n is the coefficient of roughness of bed. Solving equation 1, we have

$$A = \frac{Q}{V} = \frac{Q}{C\sqrt{RS}} \quad \ldots\ldots (2)$$

If a simple method can be found for obtaining the value of V, then the waterway can be found by dividing Q by V.

Table III. gives the values of V for slopes varying from 0.1 ft. per thousand to 20 ft. per thousand; for values of R from 2 ft. to 25 ft. for the case where n = 0.035. It covers all the cases of flood flow of ordinary streams.

From Fig. 2, it can be seen that the hydraulic radius

$$R = \frac{A}{P} = \left(\frac{1 + 2dX}{1 + 2d\sqrt{1 + X^2}}\right)d \quad \ldots\ldots (3)$$

in which l is the bottom width of a trapezoidal section, d is the depth and X is the slope of the sides. It can be seen from equation (3) that for any given values of d and X, R approaches d as l increases; for the case of floods, therefore, it may be assumed that R = the difference in stage between high and ordinary low water. Any error in the assumption that R = range of stage makes R too large, the mean velocity too large and the computed waterway too small. A and P can generally be easily measured and thus R obtained with any degree of accuracy.

Briefly stated, this method of finding the waterway at a given place on a stream consists in finding the drainage area in square miles above the place under consideration; the greatest change in stage of the stream at this place and the slope of the surface. By multiplying the drainage area, M by q, in Table II., we find Q; dividing Q by V, found on Table III., using for R the maximum range of stage, and for S, the measured slope of surface of stream, we have the necessary area of waterway.

The greatest error in the use of this method will result from an incorrect measurement of the slope. The formula calls for slope of surface, and surface slope of a stream is not necessarily the slope of the bed. The slope is not the same at all stages nor always the same for a given stage. If the place under consideration is near the mouth of a large tributary, the slope of the main stream will be affected by the stage of the tributary. Overflow and flooding of lowlands is frequently the result of backwater due to reduction of surface slope. The smaller the slope used, the greater will be the computed waterway.

If there is a possibility of the waterway becoming partly clogged with drift, logs or ice, or its being in the influence of backwater from a tributary, the computed area must be increased by a liberal amount.

Table II.—Values of q, the Maximum Rate of Flow per Square Mile of Streams in Terms of M the Drainage Area in Square Miles in the Equation:

$$q = \frac{46790}{M + 320} + 15$$

M	1	5	10	20	50	100	250	500	750	1000	2000	3000	4000	5000	7000	10000
q	161	159	157	153	142	126	95	72	59	51	35	29	26	24	21.4	19.5

CONCRETE SEAT-BANK CONSTRUCTION IN THE CHICAGO ORCHESTRA BUILDING.

The auditorium of the new Chicago Orchestra Building is notable for the special effort made to secure thoroughly fireproof construction. The structural work—steel framework, concrete floors, brick walls, fireproof partitions and hollow-tile roof—is entirely fireproof in all its details; in addition, the finish and decorative work have been made fireproof as far as possible. The ornamental balcony fronts, the partitions between the boxes, and other light portions of the work, are of plaster on wire lath. It was at first intended to have the stage and the raised banks for the musicians also built of concrete, but for acoustic effect it

TABLE III.—Table for Finding the Mean Velocity in a Channel from Kutter's Formula when "n," the Coefficient of Roughness, is taken as 0.035.

Slope in ft. per M.	Hydraulic Radius. 2	4	6	8	10	12	16	20	25
0.1	0.6	1.1	1.5	1.8	2.2	2.4	3.0	3.6	4.1
0.2	0.9	1.6	2.0	2.5	2.9	3.4	4.2	4.7	5.5
0.4	1.3	2.2	2.8	3.6	4.1	4.8	5.7	6.6	7.6
0.6	1.6	2.7	3.5	4.3	5.0	5.7	6.9	8.0	9.1
0.8	1.8	3.1	4.0	4.9	5.8	6.6	7.9	9.2	10.2
1.0	2.1	3.6	4.6	5.5	6.5	7.4	8.8	10.2	11.6
1.5	2.5	4.3	5.5	6.7	7.9	9.0	10.8	12.5	14.0
2.0	2.9	4.9	6.4	7.8	9.1	10.3	12.3	14.3	16.4
3.0	3.7	6.0	7.8	9.5	11.2	12.8	15.0	17.5	19.8
4.0	4.2	7.0	9.1	10.9	12.8	14.6	17.7	20.2	
6.0	5.0	8.5	10.7	13.7	15.4	17.7	21.5		
8.0	5.8	9.6	12.6	15.6	17.8	20.4			
10.0	6.5	10.7	14.0	17.3	20.0				
15.0	8.0	13.3	17.8	21.0					
20.0	9.3	15.3	20.0						

was eventually decided that wood must necessarily be employed for these parts. The interesting steel framework has already been illustrated and described in detail in these columns (see Eng. News of Nov. 3, 1904). The concrete work of the floors and seat-banks of the overhanging tiers, which is also unusual and noteworthy, is described in the following:

A section of the balcony floor is shown herewith in Fig. 1, and represents the typical concrete construction. The steel framework of the main floor and the three overhanging tiers (box-tier, balcony and gallery) carries a 3½-in. inclined floor slab of cinder concrete. In the gallery and balcony the banks for the seats are also of concrete, and this plastic material was well adapted to the varying shapes and peculiar conditions. For instance, the inclined floors present warped surfaces, they are of steep pitch, and the pitch is steeper at the sides than at the middle, while laterally there is a slight fall from the center to the sides. These conditions, together with the stepping of the floors to form banks or benches for the seats, and the segmental plan of these banks, made a combination of conditions which was most satisfactorily met by the adoption of concrete.

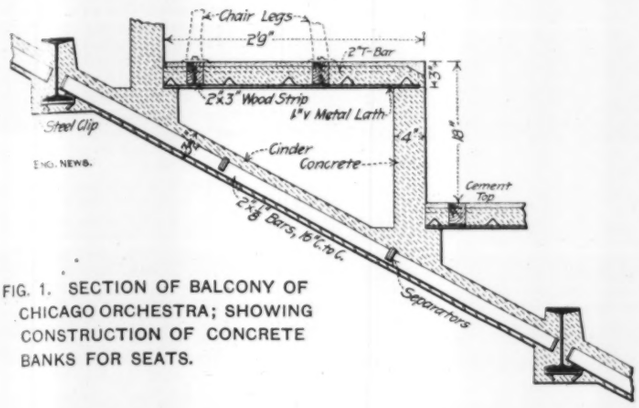


FIG. 1. SECTION OF BALCONY OF CHICAGO ORCHESTRA; SHOWING CONSTRUCTION OF CONCRETE BANKS FOR SEATS.

The design and construction of the molds for the curved rows of banks was, perhaps, the most difficult part of the work. The banks were all formed on segments of concentric circles, the radius of each bank being 2 ft. 10 ins. greater than the radius of the bank next in front. In building the forms for the front of each bank it was impracticable to build them in place, as the center from which the radii were struck was inaccessible, while the pitch of the balconies was so great as to make it difficult for the workmen to handle themselves, without trying to handle material. In addition to this, the limited time allowed for completion made it necessary to have the forms built ready to set in place as soon as the inclined slab enclosing the steel framework was completed.

The forms for the banks were built in sections 8 ft. long, as shown in Fig. 2. Two stringers 1 x 6 ins., 7 ft. 10 ins. long, were taken, and vertical strips were nailed at each end. Then the blocking strip A was placed at the center and built out the distance X. This distance had been determined by taking the versed sine of an 8-ft. chord for each circle, tabulated in the office, the table being given to the foreman carpenter. The ½-in. sheeting boards were then applied and took the proper curves, after which the intermediate blocking pieces, B, were slipped in until they became tight, and were then nailed in place. These pieces were necessary as the ½-in. sheeting was not stiff enough in 4-ft. lengths. The completed 8-ft. sections of the forms were hoisted into place.

Fig. 3 is a view of the balcony showing the concrete banks for the seats and the steps for the aisles, after the concrete work was in but before the iron seat frames were put in position. The openings seen in the risers of the upper banks connect with the ventilating and heating ducts. The gallery, which is of much steeper pitch than the balcony, is visible at the top of Fig. 3; below is seen the row of private boxes.

Some of the stairways for the aisles have had grooves cut in the backs of the treads for wooden strips to which carpets are secured; this was not originally planned, and some of the stairways are left uncarpeted. The seat frames are secured by screws through the feet, as in the usual way for wooden floors; here, however, there is no exposed wood, but a strip is embedded in the bottom of the concrete, holes being easily drilled in the concrete for long screws which extend down to the wooden strips. This is shown in the section in Fig. 1. Where hand rails are required, iron sockets for the posts were set in place in the concrete.

The floor concrete is composed of 1 part Portland cement, 2½ parts sand and 5 parts cinders, with a finishing course of 1 cement to 2 sand. It was mixed very wet in a Foote concrete mixing machine, and hoisted in buckets by an electric hoist, the space in the building not permitting the use of the usual material hoist or elevator. Owing to the time limit imposed by the owners in their desire to have the building opened by a certain date, the forms were not left in place as long as the contractors would have wished. In some cases they were taken away only 24 hours after the concrete had been deposited. This undue haste and the consequent rushing of all work led to other difficulties, especially in regard to the finished appearance of the concrete, as it was impossible to keep the employees of other contractors off the concrete while it was still green. In fact, the seats in some portions were put in place within 24 hours after the concrete had been filled into the molds.

As seen by the cross section, Fig. 1, the seat banks are hollow, the spaces being used as ducts for the heating and ventilating system. It was impossible to lay the concrete floors of the seat banks in place on wooden lagging, there being no way of removing the lagging afterward. It was necessary, therefore, either to mold these slabs separately or to use a lagging which could remain in place. As seen by the drawings, the latter plan was adopted. Sheets of close-warp wire lath, 18 ins. wide, with a 1-in. V-rib woven in at 7½-in. intervals, were laid on 2-in. steel tee-bars which were spaced just far enough to catch the lath. These tee-bars were rolled from sheet steel and are known as Rapp tee-bars. This permanent centering was used to carry the concrete as laid, and also to form the reinforcement.

The work was carried on by three shifts of men, working day and night, and with the exception of the inclined slab floors, but including the cement finish, was completed in about ten days.

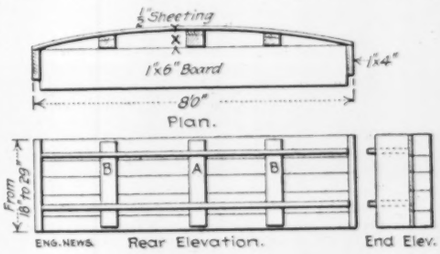


Fig. 2. Form for Curved Concrete Banks for Seats.

All the concrete structural work was done by the Roebling Construction Co., of Chicago, and we are indebted to that company for drawings, photographs, and other information.

FAILURE OF A BRIDGE PIER ON THE PHOENIX & EASTERN R. R.

By C. K. Conard.*

On Monday, March 20, the Phoenix & Eastern R. R. bridge across the Salt River near Tempe, Arizona, was wrecked by the failure of one of the piers. Two steel trusses of 200-ft. span each were dropped into the river, and will prove nearly a total loss. The damage is estimated at $40,000. This bridge was a new structure, having been in use less than a year. It consisted of four 200-ft. spans, and one of 160 ft., aggregating 964 ft. across the river bed. On the north (to the left in the picture) the approach is over a trestle about 1,000 ft. long and 25 ft. high. On the Tempe side a short fill meets the bridge.

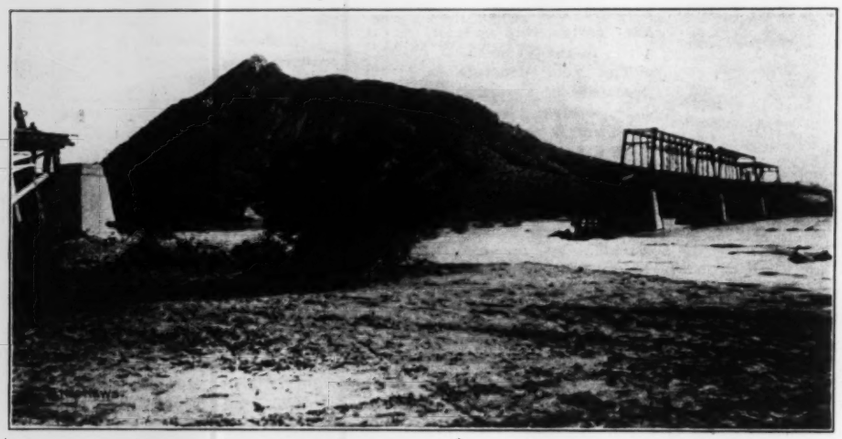
The piers are concrete, with a 60° nose on the upstream end. The batter on all faces is 1 in 12. The one that failed, being in the channel, had the

*324 E. Fillmore St., Phoenix, Arizona.

FIG. 3. VIEW OF BALCONY LEVEL, CHICAGO ORCHESTRA; SHOWING CONCRETE BANKS AND STEPS.

deepest foundation, the bottom being 10 ft. below the river bed, on ordinary occasions. Piles were driven about 30 ft., with 4 ft. embedded in the footing.

At the time of the accident the river was at flood height, and running over twelve miles an hour. It is reported that drift wood collected against the pier in question, which stood directly in the middle of the channel. The bottom here



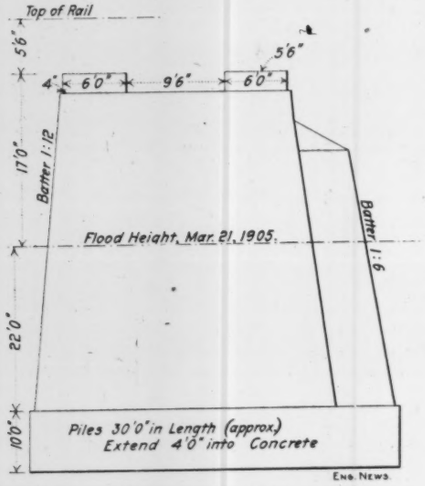
WRECK OF BRIDGE NEAR TEMPE, ARIZONA, PHOENIX & EASTERN R. R.

is described as being almost quicksand, and the scouring action must have been excessive.

A quarter of an hour before the accident a passenger train crossed the bridge, there being not the slightest doubt as to its safety. No one saw the pier give way, but the crash was heard, and the first observers believed that the train had gone down in the wreck.

The concrete appears to be of good quality, as the anchor bolts were either sheared off or ruptured close to the surface of the bed-plate blocks on the shore-end piers, crushing the material only slightly. The writer picked up a piece of one of the bolts that had been crushed off within an inch of the surface of the concrete. It still retained a full metallic luster where it had been in contact with concrete, without any sign of weathering. The bed-plate and rollers on the adjoining south pier were left intact. The truss had evidently been simply pulled off the pier.

The exact nature of the failure is not known. Whether the scouring was such as to weaken all



Elevation of Concrete Pier of Tempe Bridge.

the piles, or whether the action was confined to one end until the pier toppled over can not be ascertained from the position of the wreck. The design of the piers, with flat ends downstream, for a river with a sandy bottom, seems faulty, whether it caused the trouble or not. The eddies created by the strong current must have exerted great scouring action at the downstream end, possibly enough to have undermined the foundation at that point. The fact that a train had just passed over the bridge would indicate that the weakness was not general.

The clearance was over 16 ft., so that the superstructure of itself was in no danger at any time. In 1891 the stage of the river was 5 ft. higher, and two wooden trusses of the Maricopa & Phoenix R. R. bridge 1,500 ft. downstream from the Phoenix & Eastern bridge were carried away. The piers, however, remained intact, and are in use to this day. These piers are of the Cushing pile-foundation design, the iron tubes being 4 ft. in diameter. This design must be satisfactory to the company, as a steel structure is being built beside the old wooden one, using the same type of pier. The new tubes have a diameter of 6 ft., however.

COST OF MAKING AND PRICES CHARGED FOR CONCRETE BUILDING BLOCKS AND FOR SIDEWALKS IN IOWA.*

By L. L. Bingham.†

To obtain a reliable series of figures, from which reasonably accurate averages might be struck on many points of common interest relating to cost of manufacture and selling prices of cement products, lists of 36 questions were mailed to 112 building block and sidewalk men, mainly in Iowa, but a few also in Minnesota, Illinois, Missouri, and Nebraska points, requesting their co-operation. As in laboratory work, decided extremes among the answers received have been rejected, the time being too limited to inquire into the evident unusual conditions on which they were based.

Owing to the lack of uniformity in size of the main blocks made on different building block machines, it was necessary to first reduce the information gathered to terms of wall face feet. For instance, since each block 8 ins. high and 24 ins. long contains 1⅓ sq. ft. of wall, if an informant stated that he made 100 such blocks per day, his daily make was tabulated at 133⅓ sq. ft. of the thickness of wall given. 9-in. and 10-in. walls were classed together as 10-in., the divisions considered being 8-in., 10-in. and 12-in. walls. More replies having been received relative to 9-in. and 10-in. walls, that size will be taken as typical.

The cost of sand at the different factories ran from 0 to 4½ cts. per sq. ft. of wall, ranging mainly from 1½ to 2½ cts., and averaging within a small fraction of 2 cts.

By an oversight, the question of per barrel cost of cement in the different towns was omitted, but it is probably safe to arbitrarily fix it at $1.60, and interested persons should note the difference when comparing results with their own. On this per barrel cement cost basis, and figuring the number of blocks per barrel made at the different factories reporting, we find the seemingly very wide range of 3 to 7½ cts. per sq. ft., due partly to different percentages of air chamber, but mainly to the proportions of cement and sand. The average was a trifle over 4½ cts. per sq. ft. for cement.

The labor expense of making blocks includes not only the actual process of molding, but also the sprinkling, and any necessary repiling, during or after curing. This was made very clear in the questions sent out. The average wages paid at the different factories for skilled and unskilled labor was found to be $1.83 per day, and their average output 48¼ sq. ft. per man, or a labor expense of 3 4-5 cts. per sq. ft.

Summing the averages of 2 cts. for sand, 4½ cts. for cement, and 3 4-5 cts. for labor, we have practically 10 cts. per sq. ft. of face of wall as the average Iowa material and labor cost of cement blocks for a 10-in. wall. This is true, of course, only in so far as the various replies received are indicative of actual conditions generally obtaining over the state.

Labor and material are, however, not all the items entering into the cost of production, and any manufacturing concern which stops with them will sooner or later wonder where it is at. Interest, depreciation, repairement and incidentals must also be taken into consideration: Interest on money invested in ground, factory, machinery, molds, etc.; depreciation of the plant and tools through natural wear; replacement made necessary by the rapidity with which the machinery of this growing young industry becomes antiquated—only a few months sometimes between the purchase of one machine and the invention of a better; and lastly, incidentals, the cost of whose yearly aggregate only one who has kept accurate accounts has any conception.

These supplementary but exceedingly important factors in cost production depend so entirely upon local conditions as scarcely to admit of satisfactory average computation. One man may use railroad ground for his site, put up $200 worth of shedding, have a $300 outfit, let his bills run, plan to sell out to a stock company before purchasing another machine, and for the same reason keep down his incidental expenses. Another man whose present rate of production is no greater, may own a site worth $1,000, on which, with a view to the future, he has erected a permanent factory at a cost of, say, $2,500, equipped it with an outfit costing perhaps $2,000 more, and put another $2,000 into the bank for working capital, and invested liberally yet wisely in advertising, subscription to trade papers, purchase cement library, postage, investigation and convention trips, etc. To many Iowa block factories, even this outlay would seem small, but they are of heavier producers. Within the range of conditions covered by the two imaginary cases cited is an actual one which may give force to this importance of taking into consideration the supplementary cost items mentioned.

In collecting the material for this paper, I was permitted to look over the books of a firm which last summer made 40 car-loads of building blocks, and nearly 30,000 sq. ft. of walk, besides doing some other work on the side. They had kept a very carefully itemized record of the business, entering separately plant cost and equipment, sand, cement, labor and incidentals. This last item footed up for the season $1,099.41. Supposing that but half of this incidental expense was properly chargeable to the building block department, and adding to that the interest on $2,500 invested in the plant and equipment, putting in $50 for the season's block breakage bill, and $200 for depreciation and replacement, and dividing this total by the 20,000 sq. ft. of blocks made, it gives us within a fraction of 5 cts. per wall face foot as the legitimate and proper increased expense to add to the 10½-ct. material and labor cost we have found to be the average, or a total actual manufacturing expense of 15½ ct. per foot per 10-in. wall. This 5-ct. supplementary cost is, however, simply one firm's experience, and hence is interesting and suggestive, rather than authoritative, as applied to block manufacture in general.

The labor and material cost of 8-in. wall blocks average just about 1 ct. per sq. ft. of wall face less, and of 12-in. 1 2-3 cents more than for the 10-in. wall. Selling prices for small lots or large contracts varied only slightly, but ranged from 12¾ to 22½ cts. for 8's and 10's, and as high as 33⅓ cts. for 12's, with an average of 17½ cts. per sq. ft. for 8-in. wall blocks, 20½ cts. for 9 and 10 in., and a fraction less than 26 cts. for 12 in. The per foot labor and cost of laying the blocks in the wall varied from 2½ to 9 cts., with an average of 5 cts. Prices charged per lineal foot for window sills and caps average 38½ cts., coping 32 cts., belt course 35 cts.

Now very briefly as to cement sidewalks. They deserve a separate paper, for the proportion of men engaged in that line is far greater than in building block manufacture. I have space left, however, for only the bare statement of tabulated returns to the questions sent out, and with reference only to the cost of construction of 4-in. sidewalk. The prices for sand and gravel varied from 40 cts. to $2.25 per cu. yd. on the job, making an average per square foot cost of 1½ cts.

For the reason already given, and because a very large proportion of sidewalk men purchase locally, the cement cost has been estimated on a per barrel basis of $2. Some are paying more, others considerably less; but on that basis the average cost for cement is 3 3-5 cts. per sq. ft. —variations being due to differing proportions of sand and cement. The labor expense was based on each informant's statement of the number of men working in a crew, their wages, and the average number of feet put in per day. This gives an average per square foot labor cost of 2 1-5 cts.

The necessary supplementary cost items in sidewalk work are of course much smaller than in building block estimates, being chiefly the replacement of forms and stakes, canvas and paper covers, tools, mixing boxes or

*Condensed from a paper read before the Iowa Cement Users' Association and published in "Concrete" for March.

†Estherville, Iowa.

plat[illegible]s, interest, etc. A fair estimate in my own experience was 0.6 ct. per sq. ft. If this tallies with the experience of others, it would indicate a total average construction expense throughout the state of practically 8 cts. per sq. ft.

Prices obtained range from 8 cts. to 16 cts., running mainly from 10 cts. to 12½ cts., and averaging a trifle less than 11½ cts.

Prices for 6-in. crossings averaged 18 2-3 cts. per sq. ft.; for curbings 33 cts. per lineal foot; for gutter 17 cts. for residence steps; 45 cts. per lineal foot for each step, those with sides doubtless constituting the 50 ct. to 60 ct. class. Average prices charged for heavy cement work were: Culverts and small arches, 27½ cts. per cu. ft.; abutments, 23⅓ cts.; machinery foundations, 23 cts.

In closing, I wish to call attention to just one point, namely, the possibility in a great many instances of reducing the labor item in the cost of production. Not by paying less wages; for good, energetic, careful workers are more often deserving of a raise than a cut; but by judicious selection of the men, wise planning of the work, and in case of building blocks, convenient arrangement of factory and storage yard. For instance, in the making of 4-in. sidewalk, three contractors, none of whom reported the putting in of any sub-walk drainage filling, stated that their labor expense was over 3 cts. per foot—an unnecessary expense as compared with the average $3 and $4 per day. Two building block men, using the same make of molds, working on the same sized blocks, and both paying their men $1.75 per day, reported a labor expense difference of nearly 2¼ cts. per block.

A NOVEL COAL-CUTTING MACHINE.

We illustrate herewith a radial coal-cutting machine recently put upon the market by the Ingersoll-Sergeant Drill Co. As will be seen in Fig. 1, the machine is mounted on a column, very much like an ordinary rock drill used in stoping Indeed, one of the great merits of the machine lies in the fact that it can be quickly converted into an ordinary rock drill when so desired.

The radial cutter is designed especially for the work of shearing and entry driving. It is light and may be quickly moved and mounted. As an undercutting machine it is adapted for undercutting headings to any desired depth at a single setting. The cut is 8 ft. deep, and diminishes from a width of 4½ ins. at the face to 2 ins. at the bottom.

As the machine is mounted on a vertical column, it can be raised or lowered to undercut at any point between the roof and the floor. Thus it can be applied to slate bands, leaving the coal that is mined free of impurities.

While only lately brought before the public, the manufacturers state that this radial coal cutter has been in severe experimental service for a long time in some of the largest coal mines in the country.

AN INTERNATIONAL CONGRESS OF TECHNICAL Education is to be held at Milan, Italy, in 1906. The exact date of the meeting has not yet been fixed, but as it is proposed to hold at Milan in the same year an International Congress of Commerce and Industry, it is probable that the dates for the two congresses will be made about the same.

LINE CONSTRUCTION FOR HIGH-PRESSURE ELECTRIC RAILROADS.*

By George A. Damon,† Assoc. Am. Inst. E. E.

The single-phase high-pressure trolley has arrived and evidently has come to stay. The advantages gained by delivering energy directly to a car without the necessity of an investment in synchronous converters and heavy feeders has long been recognized. That it is entirely practicable to take current from a high-pressure conductor by means of a moving contact has been fully demonstrated. It has required some time to show that there is a field for a single-phase traction motor sufficiently promising to justify its commercial development, but a number of motors of this type are now upon the market and within the last few weeks have been put in actual every-day operation.

To get the full benefit of the new system, it is desirable to carry as high a pressure as practicable on the trolley wire. It is apparent at once that the methods of installation which have become standard with the 500-volt system are inadequate for the new conditions. Several methods of supporting the high-pressure trolley wire have already been developed, and now the time has come to standardize the pressure and the location of the current conductor, as well as the method of current collection in order to provide for an interchange of equipment. It is the object of this paper to present a brief record of what has already been accomplished in line construction, and to examine the requirements and difficulties of installation in order to obtain permanent insulation at reasonable cost, safety to the public and reliability in service.

The successful use of a single high-pressure trolley wire will have a marked stimulus upon three distinct branches of the electric railroad art: (1) Moderate-speed and inexpensively equipped electric lines for country districts. (2) High-speed interurban roads for service between large centers of population. (3) Electrification of steam railroads. This will leave the city systems with their suburban extensions to be served, for the present at least, by the direct-current motor. In studying the methods of line construction, it will be desirable, therefore, to keep in mind that each of the three classes of roads indicated will have its own individual problems and requirements.

For moderate-speed lines in the country districts, the full benefit of the high-pressure system will be obtained only when the first cost of such a road has been reduced to a minimum, consistent with good work. A study of the map, Fig. 1, which shows the electric railway situation in the middle Western States, will emphasize this point. It will be seen that nearly all the territory which promises even a fair return on the investment has been pre-empted and that some roads are even now being built where there may be some doubt as to their being able to stand the fixed charges resulting from the cost of the illogical synchronous converter sub-station system. There are still left whole sections of rich productive agricultural districts which will remain unserved by a trolley road until a system has been developed which is so simple in its requirements that it can be built and equipped complete for less than $15,000 per mile, and operated on a basis equally economical. This class of installation means a trolley pressure as high as possible, as well as transformer substations operating without attendance and working in parallel from one transmission line.

For high-speed interurban roads the high-pressure trolley opens up new possibilities. Heavier cars with more powerful motor equipments can now be operated at high speeds between cities without prohibitive first cost. "Limited" electric train service with speed schedules of 60 miles an hour from the heart of one city to another will soon be in vogue, and without the necessity of changing from third rail to trolley in passing from private right of way at corporate limits.

The electrification of steam roads will present a different set of conditions. Here the steam locomotive will share the tracks with its electric successor for some time, and will do all it can with its acid-charged gases to destroy the handiwork of the electrical engineer. This will make the installation of a contact wire anywhere except at the side of the track a doubtful proposition, and thus calls attention more strongly to the statement that line-construction problems must be divided into classes.

It will be instructive to examine the details of construction of several high-pressure trolley lines already in operation. There are details available of three installations in Europe—Valtellina, Spindlersfeld and the Huber system. There are several other lines building in Europe, but either the details of the line work have not been disclosed or the systems adopted are similar to the ones described. In this country the overhead equipment of the Lansing, St. Johns & St. Louis Electric Ry., the Indianapolis and Cincinnati Traction Co., and the Bloomington, Pontiac & Joliet Electric Ry. will present types.

VALTELLINA RY.—This is really a three-phase road having two trolleys, but the line construction could easily be adapted for a single trolley. The line is 66 miles long, with three branches; is located near Milan, Italy, and has been in operation since September, 1902. The trolley pressure is 3,000 volts at 15 cycles. The transmission line at 20,000 volts, is carried on the trolley poles. The contact wires are fixed at a height of 20 ft. in open stretches and at 16 ft. in tunnels. The trolley wires are hard-drawn copper wires of 8-mm. diameter, and the span wires consist of galvanized steel wires of 5-mm. diameter. The span wires which hold the trolley wires, after the usual suspension method, are attached to the poles by means of porcelain insulators of a special type. The contact wire is suspended by ambroin insulators consisting of a cast-iron bell holding a steel bolt imbedded in ambroin and having a mechanical clip at its lower end. The insulators are tested to 10,000 volts. Fig. 3 shows the three forms of insulator used for the transmission line, the span wires and the trolley wire, respectively.

On tangents and on curves with a radius greater than 3,000 ft., single-bracket poles are used, as shown in Fig. 2; on curves the contact wires are suspended on double poles with span construction. At stations double-bracket poles are used. A peculiar detail is a circlet of iron with protruding spikes to prevent people from climbing the poles.

The current collector consists of a roller of electrolytic copper of 3.125 ins. diameter and 2 ft. 1.625 ins. long. The current is taken from the roller by contacts rubbing on both ends of the roller. One break of the contact wire on this line is reported, the wire falling on the roof of the car, which was thoroughly grounded and thus no harm was done.

SPINDLERSFELD RY.—This is a single-phase experimental electric line installed on the State Railroad near Berlin. The line is three miles long; it was put in operation in June, 1903. The trolley pressure is 6,000 volts at 25 cycles, single-phase system. The trolley wire is hung from two steel catenary wires with suspensions every 10 ft. The steel wires also act as current conductors. The cross-section, Fig. 4, shows the line construction completely.

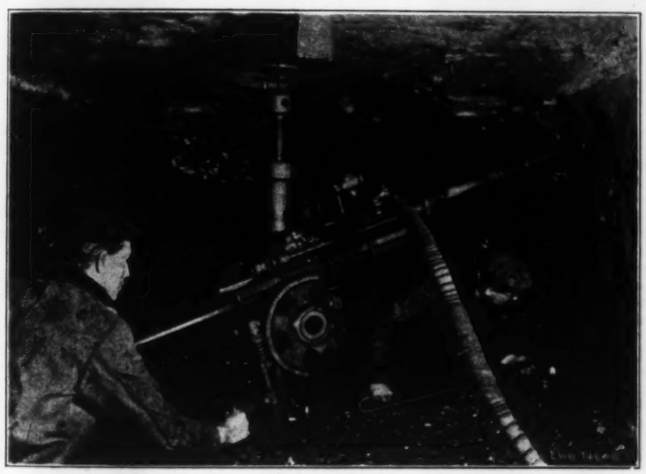


FIG. 1. VERTICAL SHEARING WITH THE RADIAL COAL CUTTER.

FIG. 2. UNDER-CUTTING WITH THE RADIAL COAL CUTTER.

*A paper presented before the American Institute of Electrical Engineers at New York, March 24, 1905.

†Electrical Engineer, The Arnold Company, Marquette Bldg., Chicago, Ill.

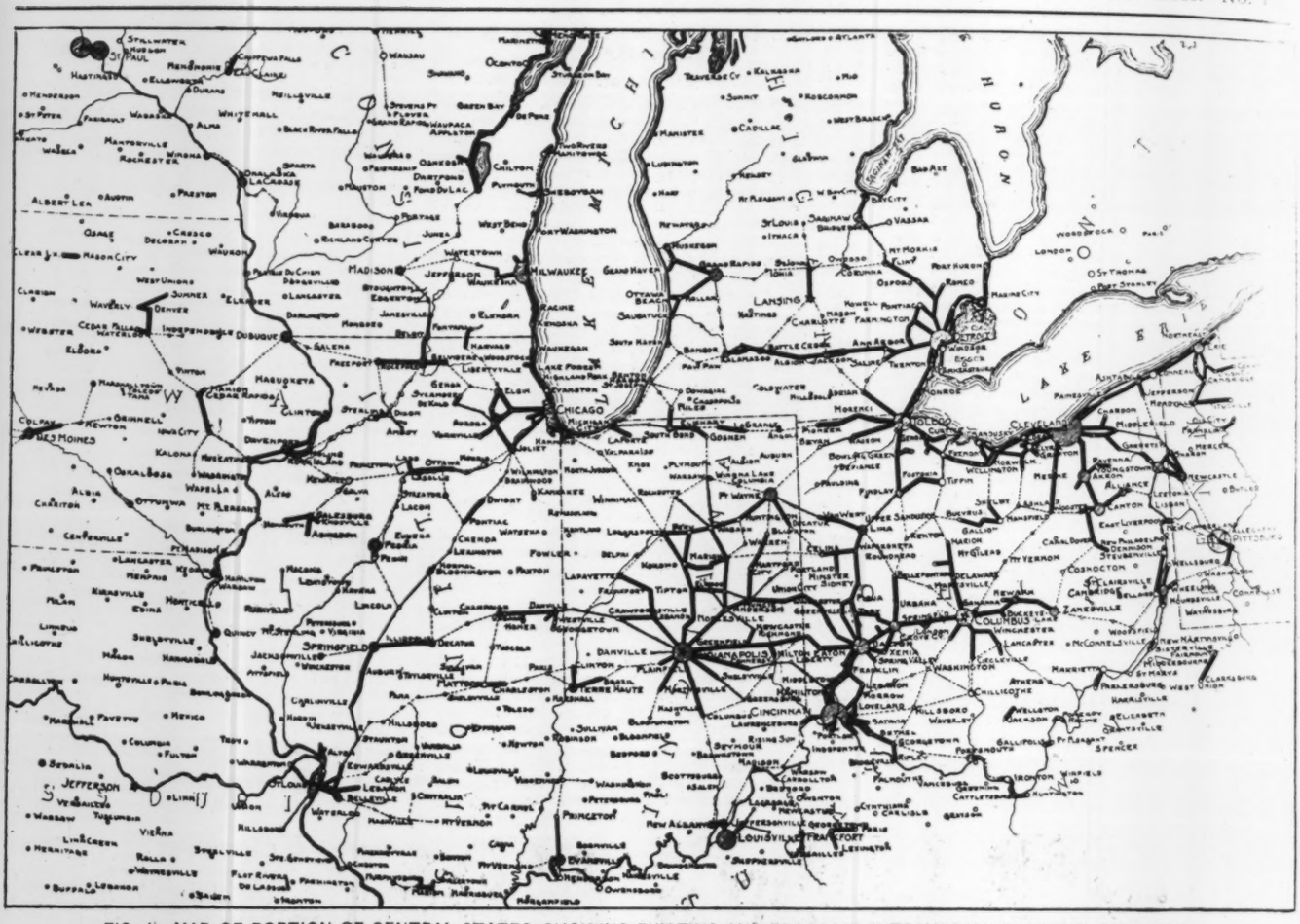


FIG. 1. MAP OF PORTION OF CENTRAL STATES, SHOWING EXISTING AND PROPOSED INTERURBAN ELECTRIC RAILWAYS.

The copper wire is of 8-mm. diameter; this seems to be the standard size on foreign roads. This wire is slightly smaller than No. 0 B. & S. gage. The contact device is a sliding bow. On parts of the line a single catenary suspension is used, the double catenary being a later development, having been adopted to insure greater safety and to increase the lateral rigidity of the conductor. The catenary wires are attached by short rubber chains to a bar mounted on two insulators and fastened to the bracket arms by means of special clamps.

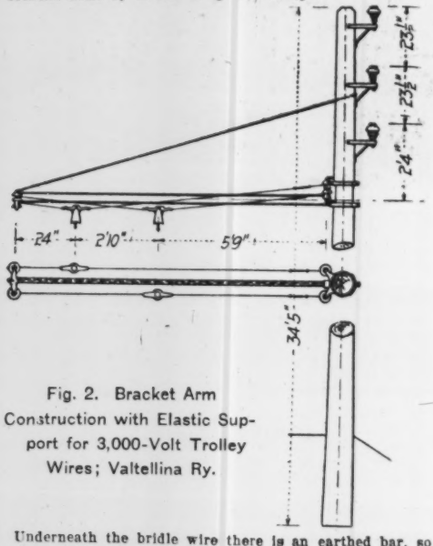


Fig. 2. Bracket Arm Construction with Elastic Support for 3,000-Volt Trolley Wires; Valtellina Ry.

Underneath the bridle wire there is an earthed bar, so arranged that a break in the line or in the catenaries will cause a contact to be made with the live conductor, grounding the system and throwing a circuit-breaker and thus protecting the line.

All telegraph, telephone, and other wires passing over the trolley, are protected by a wire cage which completely surrounds them in order to prevent any possibility of their coming in contact with the high-pressure railroad conductors.

OERLIKON CO., HUBER SYSTEM.—An experimental line has been built by the Oerlikon Machine Works after the plans of E. Huber, technical director of the company. The line uses a single-phase current at 14,000 volts directly on the conductor wire. The current-collecting device is of novel design; it consists of a curved metallic stem with its convex surface bearing lightly on the top of the current-carrying conductor. Normally the wire is located at the side of the car, but in passing through a tunnel or under an overhead crossing, the wire can be brought over the center of the track. The collecting stem has a rotary motion in a plane perpendicular to the track; the position of the stem at any time is regulated automatically by the location of the overhead conductor wire. The entire collector device is, further, mounted on a parallel link motion, which is controlled automatically so as to shift the center of the rotation of the contact stem when required. Fig. 5 shows the upper part of the collector. Some of the possible positions of the sliding arm are represented diagramatically in Fig. 6.

In making contact with the wire when over the car the collector arm rubs beneath the wire, but this is only done in tunnels and in other contracted spaces. The current collector is mounted on porcelain insulators and the light arm is held in place in such a way that it can readily be removed and renewed.

The side wire is carried in mechanical clips held in place on the top of the poles by special porcelain insulators made large enough to stand a test of 30,000 volts. Fig. 7 shows one of these insulators. The entire line has withstood a test of 16,000 volts. The average height of the contact wire alongside the track is 15 ft., and inside tunnels 16.5 ft. The distance between supports is about 100 ft.

The Huber system is being installed on the Seebach-Wettigen line, where its operation will be watched with more than ordinary interest.

SWEDISH STATE RY.—It is instructive to note that upon the experimental line authorized by the government of Sweden, and now building, a pressure on the contact wire of 6,000 volts at 25 cycles will be used.

LANSING, ST. JOHN'S & ST. LOUIS EL. RY.*—This was the first single-phase electric road to be built. It runs 20 miles north from Lansing, Michigan. The line was the scene of the pioneer single-phase work done by B. J. Arnold in 1900-1904. The line has been operated with a pressure of 6,000 volts on the trolley wire. The general method of suspending the trolley wire followed in direct-current work was adopted for this line, but the usual hanger was replaced with a large special insulator of annealed glass, tested to 30,000 volts. This special hanger was held in place on a flexible cross wire

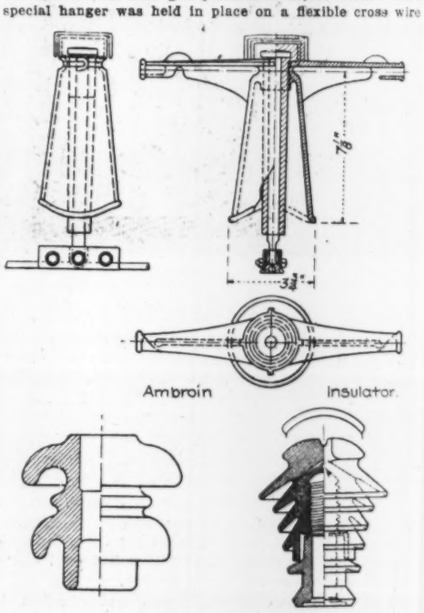


Fig. 3. Transmission Line, Span-Wire and Trolley-Wire Insulators; Valtellina Ry.

suspended between malleable-iron brackets attached to a wooden cross-arm. It was originally intended to stagger the wire supports and use a bow collector, but the experiments were finally conducted with the use of an ordinary trolley wheel. This wheel would at times slip

*See a detailed account in Engineering News of Jan. 7, 1904, p. 17.

off the wire, and the breaking of the glass hanger insulators from this cause soon demonstrated that this form of suspension was not adapted for places when there was any probability of an ordinary trolley wheel being used.

This line proved, however, that the use of trolley pressures as high as 6,000 volts were entirely practicable; and the attention which was attracted to single-phase possibilities by the early work done at Lansing had a marked influence in creating the demand for the general development of high-pressure railroad systems.

BLOOMINGTON, PONTIAC & JOLIET ELECTRIC RY.—This line will be 90 miles long, connecting Bloomington and Joliet, Ill. A section of the line was put in operation February, 1905. The trolley pressure is 3,300

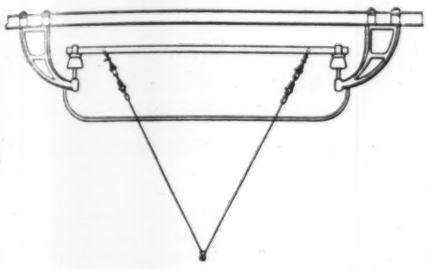


Fig. 4. Double Catenary Suspension for 6,000-volt Trolley-Wire; Spindlersfeld Ry.

volts, and the wires are held in place by catenary construction. The overhead construction is exhibited in Fig. 8, which also shows one of the insulators supporting the messenger wire. Owing to local conditions, such as turnouts, there are two No. 00 grooved trolleys over each track, each hung from a 0.375-in. galvanized steel cable. The poles are so placed that eventually they will be in the center of a double track. The brackets holding the catenary insulators are made of Washington fir, with a wooden brace underneath. The insulators are cemented on iron pins.

INDIANAPOLIS & CINCINNATI TRACTION CO.—This is a high-speed interurban line, 41 miles of which are practically finished. Sixteen miles were put into service January, 1905. The trolley pressure is 3,300 volts. The catenary form of suspension is used with one 0.4375-in. steel messenger wire supported every 100 feet by large

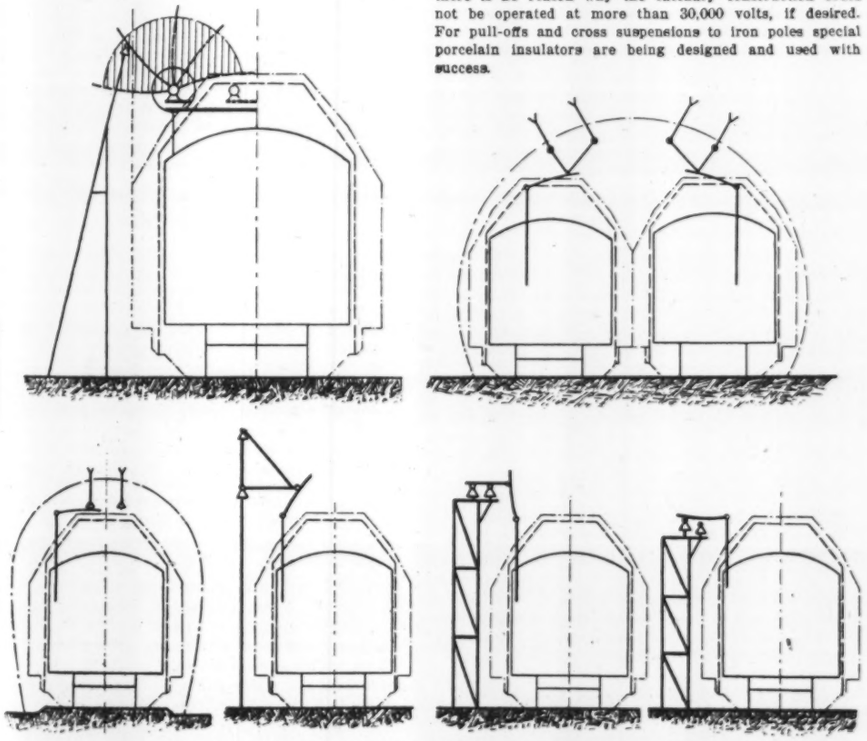


FIG. 6. RELATIVE POSITIONS OF COLLECTOR ARM AND CONDUCTOR; OERLIKON SYSTEM.

flat insulators held on an iron bracket. The copper trolley wire is No. 000 B. & S. gage and is carried eight inches under the messenger cable. The trolley is supported every 10 feet by means of special steel clamps in such a manner that the wire is held very nearly at a perfect level over the center of the track and 18 feet above the rail.

The transmission line pressure is 33,000 volts; a separate pair of wires connects the power-house with each sub-station. The trolley pole-line and the transmission pole-line are separate, the former being at one side of the right of way. The iron brackets holding the catenary insulators are made of angle-iron with a loop at the outside; this will allow for considerable adjustment in the position of the insulator. It is the intention to stagger the position of the catenary supports and thus produce a horizontal wave in the trolley line, which will distribute the wear on the bow collector, eventually to be used on this line.

REQUIREMENTS OF INSTALLATION.

Bearing in mind the distinct requirements of the three classes of roads already referred to, the problem of line construction may be discussed under the following heads: 1. Pressure and insulation; 2. Location of conductor; 3. Requirements for safety and stability. An entire paper might be devoted to any one of these subjects.

PRESSURE AND INSULATION.—The single-phase lines now in operation in this country have 3,300-volt trolleys, and several lines under construction have also decided to use this pressure. From present appearances, therefore, 3,300 volts is to be the standard for interurban lines. It would be well, however, to consider just at this time whether it would not be advisable to use a trolley pressure of 6,000 volts. From an operating standpoint there seems to be no reason why this higher pressure is not just as practicable as a lower one; and to get the full benefit of all the advantages inherent with the high-tension system the higher pressure should be adopted. Even if a few of the first roads are built with a 3,300-volt trolley, there is no reason why, with the catenary suspension, the insulation provided should not be capable of standing a working test of 6,000 volts, so that when the time comes to double the pressure, the expense of the change will be a minimum.

For steam-railroad conditions, the larger amount of energy required indicates that a pressure of at least 15,000 volts will probably be desirable. Just where to strike a balance between the cost of copper and the cost of insulation for steam-road work is a problem which should be carefully worked out; but there seems to be no reason at this time why pressures of over 10,000 volts should not be considered.

The catenary form of suspension affords so convenient a method of insulation that it should become standard practice for interurban electric lines. When selecting an insulator for this construction, mechanical strength should be the first consideration, and a few cents more spent on the insulator will insure an abundance of insulating qualities. As far as insulation is concerned, there is no reason why the catenary construction could not be operated at more than 30,000 volts, if desired. For pull-offs and cross suspensions to iron poles special porcelain insulators are being designed and used with success.

It has long been admitted that dry wood is one of the best insulators. The convenience with which a wooden rod fitted with suitable terminals can be worked into an overhead construction will commend this form of insulation. Impregnated with an insulating compound, and of sufficient length to withstand high pressure tests, the long wooden insulator is applicable to the insulation of guy wires, anchors, and cross suspension wires. Its use in actual practice will be watched with interest.

The use of a wooden bracket to hold the insulator for supporting the catenary will probably appeal to some as a step backward. As far as looks are concerned, however, it may be said that a wooden bracket of a section 3½ by 5 ins. presents an appearance fully as attractive as the ordinary cedar pole to which it is attached; and that a double-track road with a line of center poles equipped with wooden brackets will be much less offensive from an æsthetic point of view than a double row of side suspension poles raked outward in the usual fashion.

The wooden bracket has an element of safety not possessed by an iron support, as the insulating properties

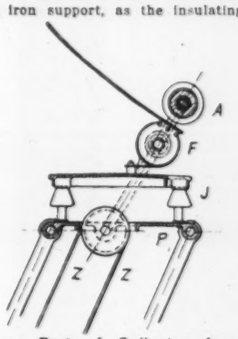


Fig. 5. Upper Part of Collector Arm; Oerlikon System.

of the wooden arm would be useful in the case of the failure of an insulator. Unless the wooden bracket were wet it would safely hold up a 6,000 volt catenary until the line could be repaired.

LOCATION OF CONDUCTOR.—For moderate speed roads the natural tendency will be to have the trolley wire where it has proved to be so thoroughly satisfactory, that is, over the center of the track, and to continue to use the present trolley-harp and wheel. For speeds not exceeding 40 to 50 miles an hour at trolley pressures up to 3,300 volts, this arrangement will work satisfactorily.

For high speed electric lines there will be little objection to the conductor wire remaining over the track, pro-

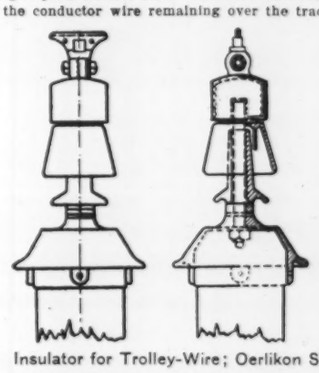


Fig. 7. Insulator for Trolley-Wire; Oerlikon System.

vided it is properly suspended; but the danger of the ordinary trolley wheel jumping off the wire at high speeds will, no doubt, suggest the use of some form of collector other than the wheel. The bow, the roller, and the shoe will each find advocates until more experience has been obtained and the results are reported and discussed.

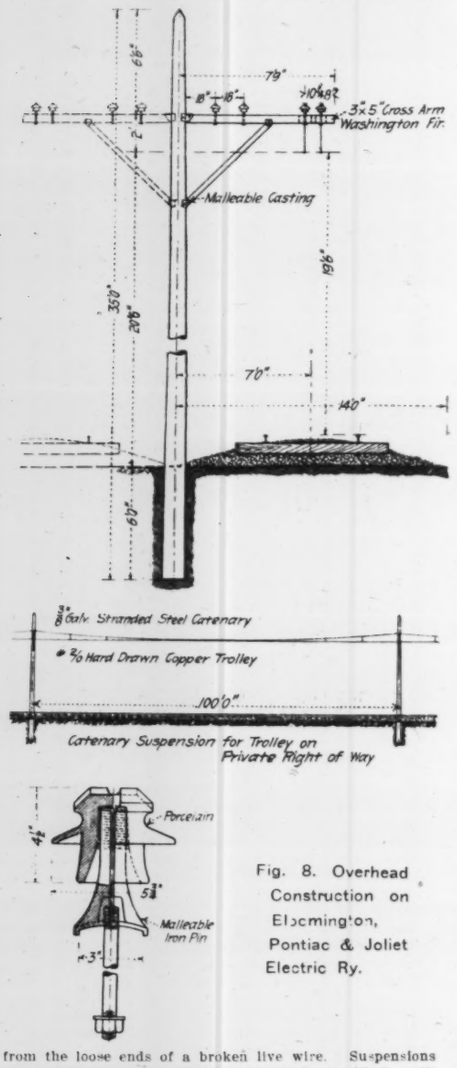
Special cases will arise such as the installation of a high-pressure conductor wire over a road already equipped with a direct-current trolley, as was the case with the Ballston, N. Y., road. (Engineering News, Aug. 25, 1904, p. 170.) In such an event the catenary construction can be very nicely adapted to suspending the wire at the side of the track. This location could be advocated for an entirely new installation on the grounds of cheaper first cost and some additional safety in case the wire should break and fall, but both these arguments lack sufficient weight to establish the wire in the side position as standard practice.

For steam-road conditions considerable objection may be found to locating the conductor wire over the center of the track; the danger to trainmen standing on top of the cars; the fouling of the conductor; the deterioration of the insulation, and the destruction of the wire and supporting cables by the gases of locomotives which may jointly occupy the tracks; the blocking of traffic when it is necessary to repair a broken wire—all these are serious drawbacks to this location of the conductor for heavy railroad practice. To avoid the deleterious effect of the locomotive gases it would seem to be imperative to place the contact wire at one side and as low as possible consistent with general safety. The advisability of installing an independent and duplicate system of conductors is also to be considered for lines of importance; this can be done only by putting the wires on opposite sides of the track.

The Huber system appears to have been carefully worked

out, and at the present time is the best suggestion for a solution of the line problems in connection with the electrification of steam roads. There is one serious objection to the arrangement, but this can be overcome. The contact wire carried from pole-top to pole-top is liable to break, and some form of support should be devised to prevent the broken ends falling to the ground. A double-catenary suspension system with one wire carried on an insulator at each end of a cross-arm attached to the pole, say a foot from the top, could be provided, and the contact wire could be supported from the apex of triangular supports attached to the two catenary wires. This method would offer advantages over any system of guard-wires or cradles which might be devised to catch the broken wire, as it would require three wires to be broken before any part of the system could fall to the ground.

REQUIREMENTS FOR SAFETY.—Whatever method of construction is followed, every precaution should be adopted to prevent accidents to the public or employees



3/8" Galv. Stranded Steel Catenary
#0 Hard Drawn Copper Trolley
100'0"
Catenary Suspension for Trolley on Private Right of Way

Fig. 8. Overhead Construction on Bloomington, Pontiac & Joliet Electric Ry.

from the loose ends of a broken live wire. Suspensions or supports properly installed every 10 to 15 ft. will lessen this danger.

With bracket construction having poles about 100 ft. apart, there will be no need of a double-catenary suspension for the wire which is to be used with an under-running collector. In such a case, the double suspension would mean twice as many insulators as would be required with the single catenary, thus decreasing the insulation resistance and increasing the chances for trouble. With what is known as the "tower" method of construction—using long spans—the double catenary, spreading at the points of insulated supports and converging together at the center of the span, will be found desirable. The necessity of keeping the wire from swaying will justify the double catenary in this case, and the fact that the number of points of support is reduced by using long spans will more than balance the use of two insulators at each support.

The frequent clips holding the contact wire are not only advantageous from the standpoint of additional safety, but they contribute to the permanency of the construction by keeping the wire almost perfectly horizontal at all temperatures, and thus avoiding the bending of the wire up and down at the support points every time the collector passes. The only disadvantage to clips holding the wire every few feet is the tendency for the trolley wheel to spark at these points. This is not a serious objection if a collector similar to the bow device is used, in which case there will be no interference between the collector surface and the mechanical clips.

In a hard sleet-storm every attachment connected to the wire will naturally be the cause of additional trouble. The arcs due to a coating of ice between the wire and the collector will be much more vicious at 6,000 to 15,000 volts than at 500 volts, but there is no occasion to become alarmed at the possible danger from this source. In this country one of the high-pressure lines using a trolley wheel on a 3,300-volt wire has already passed through a hard siege of sleet; and though the sparking was spectacular, very little damage was done. The frequent trolley supports, however, added considerably to the sparking.

Greased trolley wires are sometimes used to prevent the trouble caused by sleet. It is well known that the grease finish of an aluminum wire prevents the collection of sleet upon the wire, and it may be possible that a coating of grease on the high-pressure conductor wire would entirely obviate this trouble. It is evident that with a collector taking the current by means of a contact made on the top of the wire, as in the Huber system, the trouble from sleet would be a minimum. In those kinds of sleet storms in which icicles are formed and hang from the wire, a top-bearing collector would have every advantage, but when the sleet freezes equally all around the wire, the lighter pressure of the top-bearing contact might put the Huber collector at a disadvantage.

A SIMPLE DEMONSTRATION OF THE PRISMOIDAL FORMULA.

By S. D. B.

The prismoidal formula, widely used for the computation of volumes of irregular solids, is familiar enough to engineers, but its derivation is known to relatively few. In Crandall's Tables for Earthwork Computation a solution is given; but because the analytical method is employed, it is difficult to understand for those not conversant with the higher branches of mathematics. In the present article a geometrical demonstration of the prismoidal formula is given. A knowledge of the derivation of the formula will prove of service in preventing the use of the formula, under the impression that it gives an accurate solution, in cases of solids to which it does not apply. To further assist in this service, the geometrical demonstration for true prismoids is followed by an analytical proof that the prismoidal formula applies accurately to many solids of revolution, such as the sphere, the ellipsoid, the hyperboloid, etc.

PROOF FOR THE TRUE PRISMOID.—A prismoid is a solid having two parallel plane bases of any form, connected by a surface generated by a straight line touching the outlines of both bases. The bases may vary from each other in shape of outline, in any manner whatever, and they may have any number of sides; one or both of the bases may even have all or a part of its periphery made up of curves. When the bases have a curved periphery, the plane figures connecting them reduce to straight lines. From this definition it is seen, that prisms, cylinders, pyramids, cones, and their frustums, wedges, etc., are only particular instances of prismoids.

In the figure shown herewith the bases are, respectively, a quadrilateral and a pentagon, and the the planes connecting them are triangles. Midway between the bases a plane is passed, forming the mid-area P Q R, etc. From any point, O, of this plane lines are drawn connecting the vertices of the bases and of the mid-area (only some of these lines are shown in the figure). Denote the height or perpendicular distance between the bases by h; the area of the lower base by A_1, of the upper base by A_2, and the mid-area by A_m. An inspection will show that the construction lines divide the prismoid into pyramids. The pyramid A B C D E-O has the upper base A_2 as base and half the height of the prismoid as altitude $\frac{h}{2}$. The pyramid F G H I-O has A_1 as the lower base, and the same altitude $\frac{h}{2}$.

The remaining pyramids are of the type B G C-O, which for clearness is shown isolated. In this particular instance there are nine of these pyramids. The pyramid B G C-O is in turn divided into three pyramids; viz., O R S-G, R S C-O, and S C B-O. The pyramids O R S-G and R S B-O have a common base O R S and equal altitudes $\frac{h}{2}$.

Since B C is twice R S, the area of S B C is twice R S B; and the volume of the pyramid S B C-O is twice that of R S B-O.

$$\text{Volume ORS-G} = \text{ORS} \times \frac{h}{6}$$

$$\text{Volume RSB-O} = \text{ORS} \times \frac{h}{6}$$

$$\text{Volume SBC-O} = 2 \times \text{ORS} \times \frac{h}{6}$$

$$\text{Volume BGC-O} = \text{ORS-G} + \text{RSB-O} + \text{SBC-O} = 4 \times \text{ORS} \times \frac{h}{6}$$

The sum of all the pyramids of the type B G C-O equals in volume

$$4 \times (\text{POQ} + \text{QOR} + \text{ROS} + \text{etc.}) \times \frac{h}{6}$$

But the areas in the brackets equal the mid-area A_m; the above quantity therefore becomes

$$4\,A_m \frac{h}{6}$$

Since $\text{Volume FGHI-O} = A_1 \frac{h}{6}$, and

$$\text{Volume ABCDE-O} = A_2 \frac{h}{6}.$$

The volume of the prismoid equals the sum of the three volumes, thus:

$$\text{Volume} = [A_1 + 4\,A_m + A_2] \frac{h}{6},$$

which is the prismoidal formula.

APPLICATION TO CERTAIN SOLIDS OF REVOLUTION.—The prismoidal formula applies to a large variety of figures in addition to those

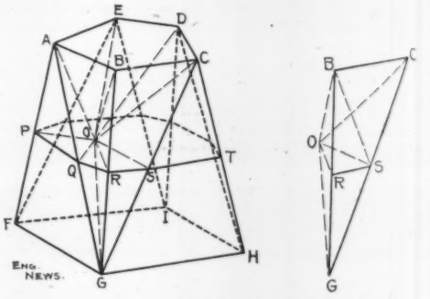


Diagram for Geometrical Proof of Prismoidal Formula.

included in the definition of prismoid. Among these are ellipsoids, hyperboloids of one and two nappes, and paraboloids and the particular cases of these solids, viz., the figures of revolution. The bases of all these solids must be perpendicular to the axis of revolution. The area of a transverse section of all the solids to which the formula applies is given by the general equation

$$\text{Area} = a + bz + cz^2 + dz^3$$

in which z is the distance of the section along the axis of the solid from a datum plane; and a, b, c, d are constants. For the transverse sections of true prismoids and of surfaces of the second degree above enumerated, the constant d is zero.

A verification of the applicability of the prismoidal formula to solids, the area of the transverse sections of which is given by the above equation, is readily made by obtaining the cubic contents by means of integration and comparing this result with that obtained by the prismoidal formula. By integration the volume V is

$$V = \int_0^h (a + bz + cz^2 + dz^3)\,\delta z$$

$$= ah + \frac{1}{2}bh^2 + \frac{1}{3}ch^3 + \frac{1}{4}dh^4$$

The bottom base is the datum plane and h is the height of the solid. The area of the bottom base is obtained, by putting $z = 0$, as

$$A_1 = a$$

The mid-area is obtained, by putting $z = \frac{h}{2}$, as

$$A_m = a + \frac{1}{2}bh + \frac{1}{4}ch^2 + \frac{1}{8}dh^3$$

The upper base is

$$A_2 = a + bh + ch^2 + dh^3$$

Using these areas in the prismoidal formula gives

$$V = (A_1 + 4A_m + A_2)\frac{h}{6}$$

$$= ah + \frac{1}{2}bh^2 + \frac{1}{3}ch^3 + \frac{1}{4}dh^4$$

Thus the result obtained by the prismoidal formula is identical with that obtained by integration, proving the applicability of the formula to a large variety of solids, the areas of the transverse sections of which are expressed by an equation of the third degree. Prismoids and figures having surfaces of the second order are only some of the solids to which the prismoidal formula applies.

HIGH-PRESSURE LINE CONSTRUCTION FOR ALTERNATING-CURRENT RAILWAYS.*

By Theodore Varney.

The chief advantage to be derived from the direct application of the alternating current to railway service is in the use of high trolley-pressures. Having a successful alternating-current motor, the remaining problem of greatest importance is the method of supplying current to the car. The third rail, which is largely used in heavy railway work, is obviously unsuited for carrying 3,000, 6,000, or 10,000 volts on the score of insulation and of safety. Moreover, the third-rail construction, whatever be the pressure, is not suitable for terminal yards in which there are many tracks and in which derailments are not unusual. A smash-up would be almost certain to result in tying up the system.

Of the various methods of current supply heretofore employed the overhead conductor is believed to be the only one capable of development into safe or permanent operation with trolley pressures running up into thousands of volts. The present paper will describe some preliminary work which has been carried out on a practical scale with overhead conductors. In laying out a suitable overhead high-pressure alternating-current system, it was decided to make a radical departure from the present methods of construction wherein the insulation is made only good enough and the supporting structure only strong enough to keep the cars running by the aid of an efficient repair department. It was rather the aim to obtain a system which would be serviceable and reliable for several thousand volts and which when once in place would at least equal in durability and cost of maintenance the bridges, tracks, and other portions of a standard railroad. While the exacting conditions and heavy traffic of the present steam roads will require for successful operation by electricity a carefully planned and substantial construction, the lighter interurban roads may frequently be equipped with a less expensive system.

Several classes of construction have been designed; of these the least expensive type employing bracket arms will be described first.

BRACKET-ARM CONSTRUCTION.

This system consists of a single line of wooden poles spaced well apart and fitted with bracket arms and steel catenary suspension cable for supporting the trolley wire. The bracket arm is a T-iron supported by a tension rod at its outer end and fitted at the inner end with lugs which partly embrace the pole and to which they are bolted with lag screws. Fig. 1 indicates the construction.

The insulator is of corrugated porcelain, cemented to a malleable-iron sleeve which in turn is slipped over the bracket arm and held by clamps and set screws. The porcelain insulator has a groove at its center surrounded by a malleable-iron collar similar to a pipe clamp. This collar has an eye on the lower side into which the hooks of a clamp which carries the steel supporting cable or messenger are inserted. Wheel trolleys will probably be used to a considerable extent with the lower pressures. Guard loops are provided to prevent breakage of the porcelain, in case the trolley should leave the wire under a bracket. The insulator with its fittings is shown in detail in Fig. 2.

The guard loops are also of service in temporarily supporting the cable while it is being run out and pulled up. The trolley and messenger are run out together, and the former is supported from the messenger at occasional points by temporary tie-wires. The tension in the messenger cable is adjusted to give the proper sag, and the trolley wire is pulled up tight enough to take out all kinks and bends. Both trolley and messenger are then anchored. The messenger is next clamped to the insulators and the trolley is permanently supported from the messenger by means of hangers or clips which are adjusted in length in such a manner as to hold the trolley horizontally. By this means, the tension in the trolley is slightly relieved and allowance is made for expansion and contraction. The hangers are stiff and, being placed only 10 ft. apart, correct any tendency of the grooved trolley wire to twist. This insures that the smooth lower surface will always be downward, a feature especially

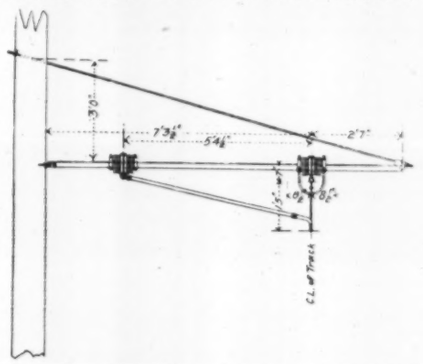


Fig. 1. Special High-Tension Trolley Line Construction with Single Suspension Catenary, as Applied to Bracket-Arm Work.

necessary when bow or sliding trolleys are used. The short distance between hangers also prevents the end of a broken trolley wire from coming dangerously near the ground.

The method of supporting the messenger below the bracket arm enables a tension rod to be attached to the outer end of the bracket without the necessity of fishing the messenger cable over the arm and under the brace. The cable and trolley may be run out along the track and pulled up in place under the brackets with a minimum amount of labor. Another advantage in this arrangement is the slightly flexible character of the point of support of the messenger; this is not sufficient to permit any considerable vibration of the span as a whole but will allow any small vibration set up by the trolley to pass on. It has been noticed in rigidly-supported spans of considerable length that a tendency exists for waves to be reflected from these fixed points which, when they reach the trolley, lift the wire from it, thereby causing flashing.

The hanger consists of a galvanized malleable-iron casting made in ten lengths. It is fitted with a bolted clamp to take the messenger cable and is secured to the

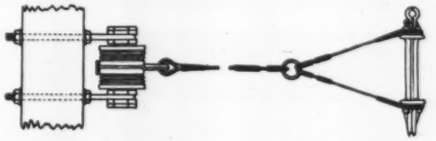


Fig. 3. Arrangement of Curve Pull-Off for Single Catenary Construction.

trolley with screws. At intervals of about 1,000 ft. and upon curves of large radius, a steadying device shown in Fig. 1 is used. The pull-off used on sharp curves, and the section-break insulator, are shown in Figs. 3 and 4.

A road five miles in length has been in operation for about five months, and upon this road several forms of construction have been installed. One portion has been equipped with 120-ft. spans with sags of 24 ins. in the messenger cable. Another section has spans of about 96 ft. and sags of about 4 ins. In the latter case both messenger and trolley wire are tighter than the former. The greatest temperature variation noted on the 120-ft. spans was 36.3° F., and the corresponding changes in height at the centers of the spans were 2.1 ins. and 1.9 ins. respectively. For the 96-ft. spans the temperature variation was 37.6° and the corresponding changes in height were 0.6 inch and 0.5 in. respectively.

The combined weight of messenger, 000 trolley wire, and hangers, averages 1 lb. per ft., which gives a tension in the messenger cable with 120-ft. span and 24-in. sag of about 900 lbs. The tension with 96-ft. span and 4 in. sag is about 3,500 lbs.

For best results with this form of construction both as regards cost and operation, the following arrangement is considered satisfactory: The spans should be 120-ft. long on straight track, reducing the length as may be necessary on curves. The messenger to consist of a 0.4375-in. galvanized Bessemer steel cable composed of seven strands and having an ultimate strength of about 6,000 lbs. The trolley wire to be 000 grooved section supported in horizontal position by hangers placed 10 ft. apart. The messenger cable is to be pulled up to a minimum cold-weather sag of about 11 ins., corresponding to a tension of about 2,000 lbs.

CROSS-SPAN CONSTRUCTION.

For conditions where bracket arms cannot be used, cross-span work may sometimes be employed. For this purpose the arrangement indicated in Fig. 5 has been designed. The difference between this arrangement and the bracket-arm construction is the substitution of a 0.4375-in. steel span cable for the bracket. Other details are practically the same.

BRIDGE CONSTRUCTION.

For the heavy service requirements of steam roads having from two to four tracks, the construction described above is not adequate; a more substantial equipment and one which will not encroach upon the present standard clearances is necessary. Obviously, the best form of support to accomplish this result is a bridge long enough to span all tracks with ample clearance on the sides and

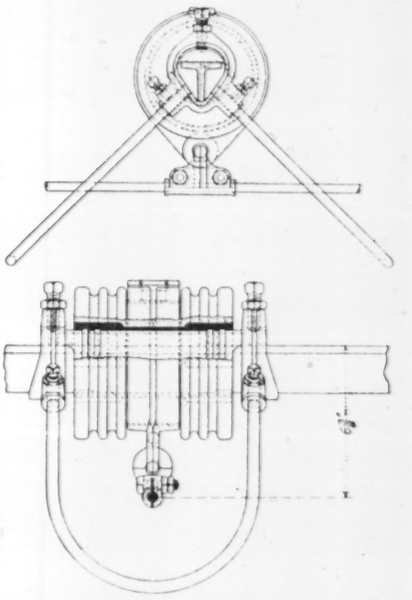


Fig. 2. Details of Insulator and Hanger for Suspension-Catenary.

overhead, and still enough to carry all of the overhead conductors without undue vibration. Bridges of this character are at present in use on many roads to support semaphores and other signal apparatus.

One track of a section 2,500 ft. long of a three-track road has been equipped with the bridge construction. The double catenary system is used, each messenger being a 0.4375-in. steel stranded cable. The trolley wire is 000 grooved, and the supporting hangers are placed 10 ft. apart. The average total weight per foot supported by each cable, including its own weight, is 0.91 lbs. The vertical sag in the first span, which is 230 ft. long, 2.6 ft., and in the second span, which is 270 ft. long, 3.6 ft., both at 26.6° F. The corresponding tension in the messenger cables is 2,300 lbs.

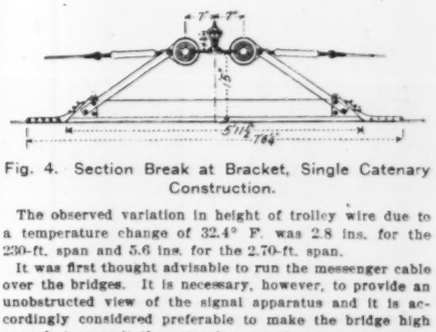


Fig. 4. Section Break at Bracket, Single Catenary Construction.

The observed variation in height of trolley wire due to a temperature change of 32.4° F. was 2.8 ins. for the 230-ft. span and 5.6 ins. for the 270-ft. span.

It was first thought advisable to run the messenger cable over the bridges. It is necessary, however, to provide an unobstructed view of the signal apparatus and it is accordingly considered preferable to make the bridge high enough to permit the semaphores to be suspended below the truss.

Fig. 6 indicates a signal bridge which has been devised for a four-track road carrying, besides the semaphores

*A paper presented before the American Institute of Electrical Engineers at New York, March 24th, 1905.

the four sets of cables and trolley wires suspended below the truss. This construction is a decided advantage in erecting, as the cable and trolley wire can be run out along the track and lifted into place. Massive porcelain insulators will be used mounted on heavy pipe and fitted with collars having soft lead strips under them. From these the cables will be hung by means of bolted clamps. By anchoring all cables to the bridges after being drawn up to a uniform tension, the effect will be to steady the

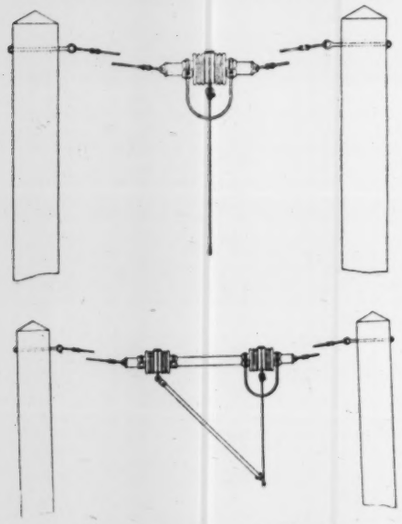


Fig. 5. Single Suspension Catenary Construction with Cross-Span Support.

bridges. For roads having wide rights of way comparatively light bridges steadied with guy cables may be used, but for most cases a substantial structure similar to those now used for signal towers will probably be preferable. It will be noted, however, that owing to the comparatively long intervals between signals only a few of the bridges carry semaphores; the others may be made lighter than the one indicated in Fig. 6.

Spans of 300 ft. for straight tracks appear to be satisfactory, not being so long as to permit undue vibration in the cables, and not so short as to require a large number of bridges per mile.

For the messenger cables 0.625-in. extra-high strength steel strands are suitable. With a 0000 grooved trolley wire and hangers spaced 10 ft., the average load per foot on each cable is 1.43 lbs., and with a vertical sag of 2.7 ft., the tension is 6,000 lbs. In a rough climate, wind and sleet will at times increase this tension; assuming that the tension may be doubled, a factor of safety of about 3.5 will still remain, as the breaking strength of the cable is about 40,000 lbs.

For use in localities where milder weather conditions may be assumed, lower grades of steel may be used having breaking strengths for the same weight per foot of 25,000 lbs. and 19,000 lbs. These latter cables are somewhat easier to handle and would be sufficiently strong for most conditions.

The sag given above is taken to be the cold-weather condition and for 100° F. rise the sag would be about 4.4 ft., or a variation of 1.7 ft. In Fig. 6, this allowance is made in the height of the bridge so that the lowest point of the trolley wire will be 22 ft. above the track. It is believed that the variation will be less than this, on account of the giving of the supports and other causes.

For curves, the length of span will be decreased; and when necessary to hold the wire in the center of the track radial pull-offs will be used, secured to strain insulators. These will be mounted on latticed poles which in turn will be braced by guy anchors.

For sharp curves, the radial pull on all the messenger cables would be severe, and it is intended to provide at the tangent points anchor bridges which will have trusses stiff enough in the horizontal plane to stand the strain of slacking off the cables about one half. These anchor bridges will then be held by long guys running out a considerable distance from the bases of the bridges and anchored to cross-ties or channel-irons buried in the ground and concreted. Fig 7 represents in outline a 500-ft. radius curve.

Several details for the double-catenary construction are shown in Fig. 8. All of the metal parts other than the bridges and trolley wire are galvanized, but as a further protection against depreciation from locomotive fumes periodical painting is advisable.

Regarding the efficiency of the insulation employed, it may be stated that under conditions of heavy snow fall, a length of 2,500 ft. of iron bridge work and five miles of single-catenary construction showed under test a leakage of one ampere at 6,000 volts.

THE NEW CHICAGO-ST. LOUIS LINE OF THE CHICAGO & EASTERN ILLINOIS RY.

The new line of the Chicago & Eastern Illinois Ry. from Chicago to St. Louis was opened for traffic on Sept. 1, 1904, making the fourth line between these two cities. The total length is 290.5 miles, of which 65% is owned and the remainder operated under trackage agreements. A map of the four lines is shown herewith. The length of the other Chicago-St. Louis lines is as follows: 293 miles by the Illinois Central Ry., 286 miles by the Wabash Ry., and 284 miles by the Chicago & Alton Ry. The new line will eventually be double track throughout, although at present it has some stretches of single track. At its southern end, from Mitchell to East St. Louis, the two single track lines of the Cleveland, Cincinnati, Chicago &

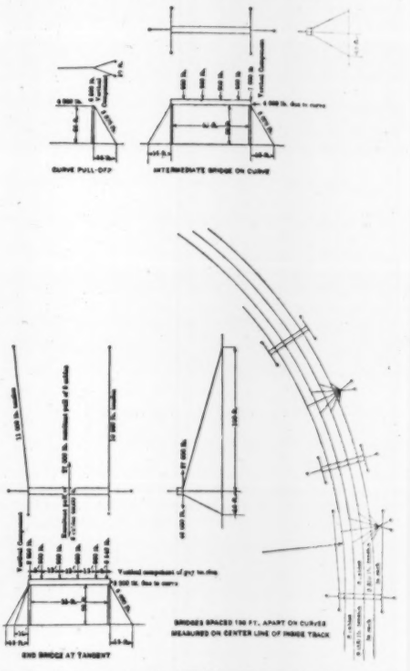


Fig. 7. Arrangement of Bridge Supports, Curve Pull-Offs and Braces on Sharp Curves.

St. Louis Ry. and the Chicago & Alton Ry. are operated under agreement as a double track line. The entire location was done under the direction of Mr. W. S. Dawley, Engineer of Maintenance of Way, Mr. F. W. Hawks being at the head of the party. We are indebted to Mr. Dawley for much of the information in this article.

It will be of interest to consider the conditions under which the new line was built. The St. Louis & San Francisco Ry. Co. has within the past few years developed a railway system which now ag-

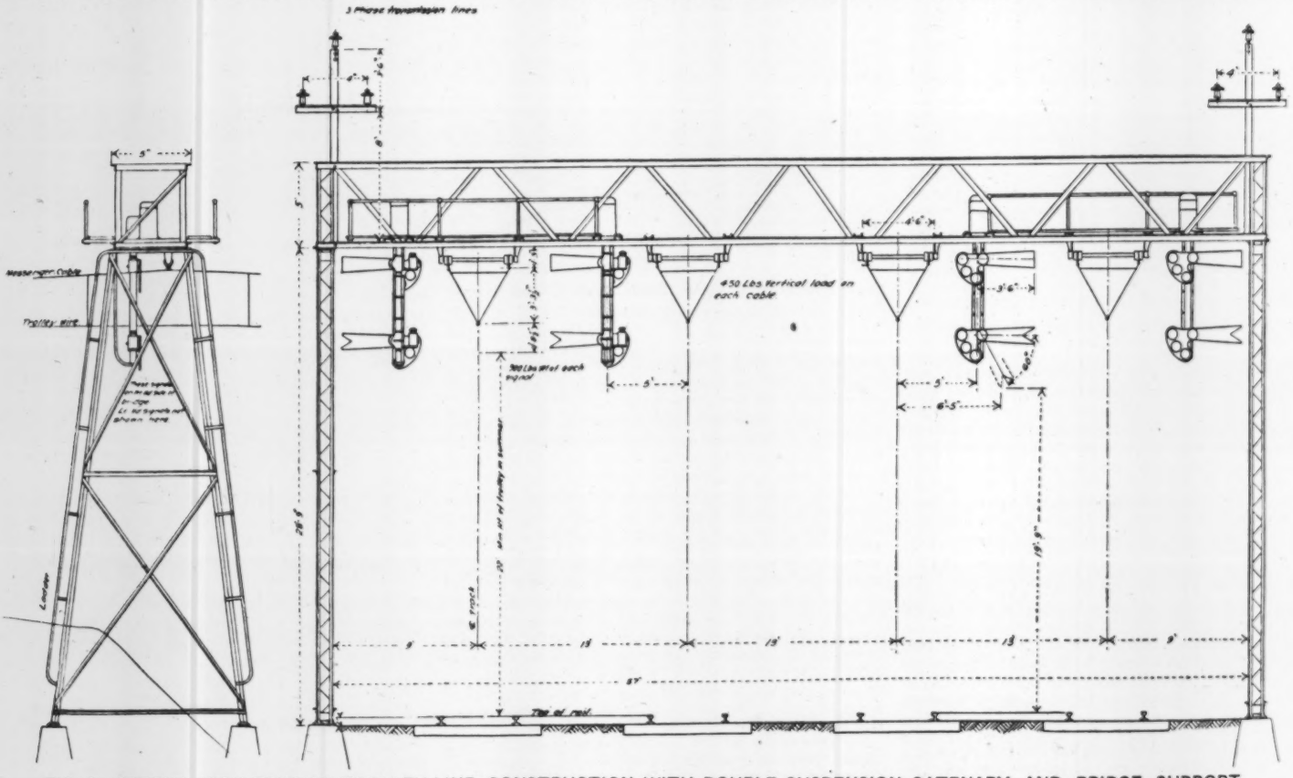


FIG. 6. SPECIAL HIGH-TENSION TROLLEY LINE CONSTRUCTION WITH DOUBLE SUSPENSION-CATENARY AND BRIDGE SUPPORT.

...gates 5,685 miles, and in October, 1902, it made ... important addition to its system by the pur... of the Chicago & Eastern Illinois Ry. At ... time it owned no connection with its new ...perty, although the great cantilever bridge ... being built over the Mississippi River at ...bes, Ill. (130 miles south of St. Louis), will ...ct such a connection, extensions having been ...t for this purpose. The principal point on the ... Louis & San Francisco Ry., however, is St. ...is, while Chicago is the principal point on the ...hicago & Eastern Illinois Ry., and it was con...ered very desirable to connect these points by ...direct line. The competitive traffic of existing ...es emphasized the importance of making the ...w line not only short, but also with favorable ...grades and alinement. Eventually it was decided ...to utilize 160 miles of existing lines and to ...shorten the distance as compared with the older ...railways by constructing cut-offs at three points, ...the saving in distance by the new construction ...amounting to 33 miles. The maximum grades are ...27 ft. per mile northbound, and 27 ft. per mile ...southbound. The sharpest curves are of 5° ...and 6°.

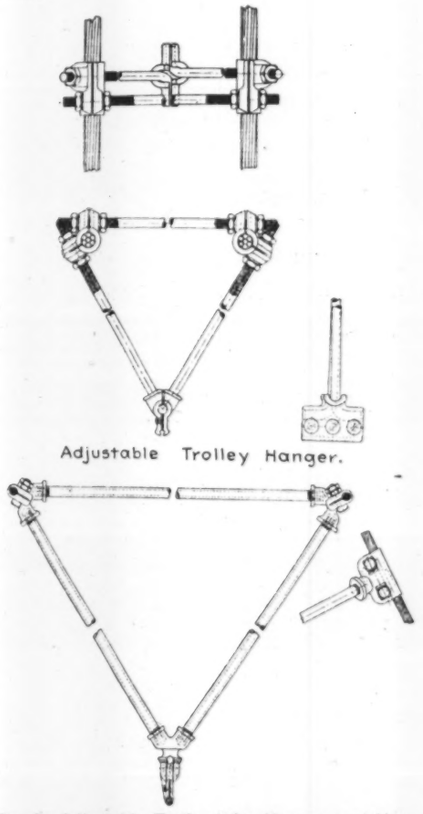


Fig. 8. Adjustable Trolley-Wire Hanger, and Hanger at Curve Pull-Off, with Double Suspension-Catenary.

The new route is shown on the accompanying map. The Chicago & Eastern Illinois Ry. has a main line running south from Chicago to Danville, Terre Haute and Evansville. From Danville it has another line running southwest to Findley, and thence south to the Thebes bridge. For the St. Louis line, a cut-off (A) of 63.3 miles was built from Woodland, on the Terre Haute line, to Villa Grove on the Thebes line; while from Findley, on the Thebes line, an extension (B) of 17.1 miles was built to connect at Pana with the Indianapolis & St. Louis division of the Cleveland, Cincinnati, Chicago & St. Louis Ry., over which trains were run to East St. Louis. This end of the line, however, was not favorable to fast service, and in connection with other improvements for the St. Louis Exhibition traffic, the Cleveland, Cincinnati, Chicago & St. Louis Ry. decided to build a better and more direct line (C) from Hillsboro to Mitchell, 45 miles; this effects a saving of 13 miles in distance, besides securing more favorable grades and crossings. The terms of the contract for the use of this line from Hillsboro to Mitchell are that the Chicago & Eastern Illinois Ry. will pay as rental 2% per annum of the appraised value of the old line and 2% on actual cost, plus 5% per annum additional of the new line Pana to Hillsboro; and 2% of amount of bonds sold and applied to construction of the line from Hillsboro to Mitchell, plus half of the interest accruing on cost thereof during construction.

The new route is therefore made up as follows:

	Miles.
Chicago & Eastern Illinois Ry.:	
Chicago to Woodland, old line	81.8
Woodland to Villa Grove, new line	63.3
Villa Grove to Findley, old line	37.2
Findley to Pana, new line	17.1
Cleveland, Cincinnati, Chicago & St. Louis Ry.:	
Pana to Hillsboro, old line	25.0
Hillsboro to Mitchell, new line	45.1
Mitchell to St. Louis, old line	21.0
Total	290.5

As the line is intended primarily for fast through traffic, the three new sections have been built as direct as possible, and they pass through but few towns of any importance. Between Chicago and St. Louis, 26 railways are intersected, of which 10 are crossed above or below grade, 14 are crossed at grade but protected by mechanical interlocking, and two are at grade and not interlocked. On the new line, five mechanical interlocking plants were established: Woodland Junction, 48 levers; the crossing of the C. C. C. & St. L. Ry. at Glover, 44 levers; Findley Junction, 36 levers; Arthur, Ill., crossing of Vandalia Ry., 48 levers; Pana, Ill., crossing of the Illinois Central R. R. and Baltimore & Ohio Southwestern Ry., 112 levers. The plants at Woodland Junction and Findley Junction were installed by the railway company's forces; those at Pana, Glover and Arthur by the General Railway Signal Co., of Chicago.

The bridges and viaducts, etc., along the new line are as follows:

	No. of structures.	Total length, ft.
Plate girders	29	2,653
Steel viaducts	2	1,907
Drawbridges	1	214
Through bridges	3	560
Deck bridges	1	85
Stone arches	19	....
Rail top culverts	5	144
Concrete arches	28	....
Pile structures	44	3,482
Total	132	9,045

The passenger trains consist generally of five cars, hauled by engines of the Atlantic type. The trains are fitted with electric light, and an interesting feature is the use of compartment day cars. The compartments are shut off from the aisle by partitions with wide openings not fitted with doors. They are 6 ft. 8½ ins. long in the clear, and those on one side of the aisle are 4 ft. 2 ins. wide (with four chairs and a table), while those on the other side are 2 ft. 6 ins. wide (with two chairs and a table). About half the length of the car (33 ft. 6 ins.) is equipped in this way (10 compartments, 30 chairs); the other half (28 ft. 6 ins.) is arranged as an ordinary chair car with accommodation for 28 passengers. These cars are 72 ft. long over the sills, exclusive of vestibules, and are mounted on six-wheel trucks.

A. WOODLAND AND VILLA GROVE CUT-OFF.—Surveys were started on Dec. 19, 1902, and all survey work completed with the location of this 62.2 miles was completed by February, 1904, or in 42 working days, equivalent to 1.5 miles of final location for each day the party worked. Right-of-way was secured between March 15 and May 30, 1903. The cost of land was considerable, owing to the line passing diagonally through some of the best farming land in Illinois. The grading contract was let April 1, 1903, to Winston Bros. Co. and Lee & Craney, who completed the bulk of their work by Dec. 15, but the entire contract was not completed until April 10, 1904. The average daily movement of material for the entire contract under this contract amounted to 5,560 cu. yds. The roadbed was prepared, and all permanent bridges built for double track. The total earthwork quantities amounted to 1,782,550 cu. yds., an average of 28,700 cu. yds. per mile. The heavier sections occasioned by grade separations, averaging upwards of 145,000 cu. yds. per mile, were let at a different unit price.

A saving of 16 miles in distance over the old line was effected by the relocation. The alinement is essentially straight between the ends of connecting curves, except for a few slight deflections made to avoid costly farm improvements. The ruling grade northbound is 21 ft. per mile, and the length of the longest grade is two miles. The track is laid with 80-lb. rails of Am. Soc. C. E. section. The joints are of the broken suspended type, with angle bars 24 ins. long and four ⅞-in. bolts. Tracklaying was started about Feb. 20, 1904, and tracklaying and ballasting were completed August 1, 1904. The Roberts tracklaying machine was used, and under favorable conditions 4,600 ft. per day was laid. The line at present is single track, though passing tracks 3,900 ft. long have been provided at intervals of about five miles.

In the 62.2 miles there are three grade separations from foreign roads, and one interlocked grade crossing. Ten stations were built, 18 × 56 ft., of frame construction, with tile roof, costing about $1,800 each. These were built by G. A. Johnson & Son from plans furnished by the railway company.

The division yards and shops are at Villa Grove, midway between Chicago and St. Louis, where enough land has been secured for a yard of 2,200 cars' ultimate capacity, though its present capacity is 1,000 cars. A 20-stall enginehouse, small shop buildings, fuel and water stations, and a two-story brick station, costing $12,000, have been built.

Map of Railway Routes Between Chicago and St. Louis.

The longest single permanent structure on this work is a single-track steel viaduct 515 ft. long, with towers and bracing planned to permit of double-tracking in the future. This viaduct carries the railway over the Middle Fork of the Vermilion River, and the tracks of the Illinois Central R. R. The viaduct consists of 60-ft. girder spans, alternating with 30-ft. tower spans, and contains 688,900 lbs. of steel. About 24,500 cu. yds. of masonry were used in the substructure, and 1,273,000 lbs. of steel in the superstructure of permanent bridges, while 529 tons of cast-iron pipe were used for smaller waterways. Pile trestles were found to be economical at certain waterways, where the haul on material from the nearest railway station to the bridge site exceeded six miles. A total of 1,556 lin. ft. of pile bridge was thus used.

B. FINDLEY AND PANA CUT-OFF.—The grading contract for this line, 19.7 miles long, was first let Jan. 24, 1903, but was revoked and relet on May 16, 1903, to Johnston Bros., of St. Elmo. The earthwork quantities averaged about 18,300 cu. yds. per mile, and 5% of the distance was graded for double track. Concrete culverts for double track were provided for the smaller water-

ways. A total of 1,205 cu. yds. of concrete, 250 tons of iron pipe, and 637 lin. ft. of pile bridging were used on this work.

C. HILLSBORO AND MITCHELL CUT-OFF.—This relocation, 40 miles long, effected a saving in distance of 14 miles, as compared with the old line. It has no grades exceeding 26 ft. per mile, no curves sharper than 1°, and no grade crossings of other railways. The road has been graded throughout for double track, the minimum width at subgrade for both embankments and cuttings being 34 ft. The excess material from the cuts was in every instance placed in the embankments, and on sections where the embankments were in excess the cuts were widened to supply the necessary quantity of material. The total earthwork quantities aggregated 2,700,000 cu. yds., or an average of 61,400 yds. per mile. This work was let to McArthur Bros., of Chicago, on March 15, 1903, and was completed on Sept. 15, 1904, their average movement of material amounting to 5,750 cu. yds. daily. The construction was under the direction of Mr. W. M. Duane, Superintendent of Construction for the Cleveland, Cincinnati, Chicago & St. Louis Ry.

A total of 44,460 cu. yds. of concrete masonry was employed in structures on this line. At all stream crossings, arch culverts of 10 to 40 ft. span were used, having one, two or three arches. At railway crossings, standard concrete abutments with plate girder spans up to 105 ft. in length were used. Public roadways were carried through the large embankments by concrete arches of about 25 ft. span, and over the cuttings by girder bridges of reinforced concrete. The passenger stations are frame structures with concrete platforms. The track is laid with 80-lb. rails of the Am. Soc. C. E. section, laid with broken joints spliced with 24-in. 6-bolt angle bars, having the alternate nuts on opposite sides of the rail.

On this double track line between Pana, Hillsboro and Mitchell, 70.5 miles, the line has been divided into block sections 5 to 8 miles in length, and is operated on the telegraphic block system. The interlocking and block signaling plants on this line have been installed by the General Railway Signal Co., of Chicago. Each track is signaled for operation in both directions, a practice which is standard on the Cleveland, Cincinnati, Chicago & St. Louis Ry., and which is in use also on other lines. The sidings and passing tracks at block stations are equipped with interlocking plants. The distant signals are operated by electric motors, each controlled from the switch which the signal governs; in this way the objections to long pipe line connections for mechanical operation are avoided.

At Mitchell is the junction of the new double track cut-off with the old single track line, and the Chicago & Alton Ry. single track. Cross-over connections are also required, as from Mitchell to St. Louis the track of the Chicago & Alton Ry. is used by both railways as the westbound track, while the parallel track of the Cleveland, Cincinnati, Chicago & St. Louis Ry. is used by both railways as the eastbound track. Here there is a 48-lever machine with 29 working levers (12 for high signals, 3 for dwarf signals, 12 for switches and derails and 2 for movable-point frogs).

At Pana there is a much more complicated interlocking plant, covering a large area. Here the double track line of the Chicago & Eastern Illinois Ry. joins the double track of the Cleveland, Cincinnati, Chicago & St. Louis Ry., while the Illinois Central R. R. crosses both roads and the Baltimore & Ohio Southwestern Ry. crosses the Chicago & Eastern Illinois Ry. and the Illinois Central Ry., being parallel with but at some distance from the C. C. C. & St. L. Ry. This track arrangement, with its connecting spurs, switches, cross-overs and girder tracks, make a complicated system, with the outlying distant signals at very considerable distances from the operating cabin. This plant has a three-story cabin or tower with a 112-lever machine, having 83 working levers (26 for high signals, 19 for dwarf signals, 31 for switches and derails, 2 for movable-point frogs and 5 for crossing bars). These interlocking plants are on the Taylor electric system, described in our issue of Oct. 2, 1902, in which the switches are operated by electric motors.

A CONVENIENT METHOD FOR DETERMINING THE DISCHARGE OF STREAMS AND CANALS.

By J. H. Cunningham,* M. Am. Soc. C. E.

The following method for computing the discharge of streams has been used by the writer for some years, and for convenience and ease of calculation is thought to be preferable in some respects to Harlacher's method. It often occurs that the intervals between points where depth and meter readings are taken cannot be made uniform. In case a bridge is utilized it is convenient to make the meter stations midway between panel points, in which case the intervals between the shore and meter stations will generally be of an odd length. The same will hold true when a pier comes in the water. By the method here described, the intervals between meter stations may be made any convenient distance. The discharge is computed in the field without the necessity of plotting the areas; however, this may be done in the office, and the velocity area and sub-area measured with the planimeter as a check.

The accompanying table is made up from an actual gaging, and the diagram shows the graphical method. After completing the gaging the velocity areas in the fifth column of the table are calculated by the ordinary trapezoidal formula,

$$a = \frac{1\,(V_1 + V_2)}{2}$$

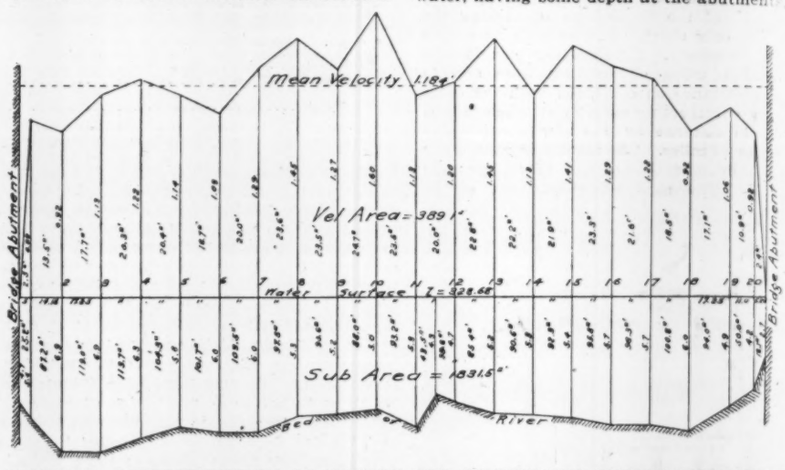
in which V_1 and V_2 are the velocities, and l the interval in feet between meter points. At the ends the velocity areas are assumed to be triangles. This would not be strictly correct for cross sections like the one here shown, where the water, having some depth at the abutments, probably has a certain low velocity; but in most cases the error caused by assuming these areas to be triangles is inappreciable. However, in the case of a flume with smooth, vertical sides, the end areas should be considered trapezoidal, as it is evident that the film of water in contact with sides may have considerable velocity. It has been the writer's practice to eliminate, as far as possible, this error by fixing the end meter stations as near either shore as the depth of water will allow, and, in case of a flume or channel with vertical sides, to assume the velocity curve as continuing about on the same curve to the sides.

After the several velocity areas are computed, they are added together, and the mean velocity for the entire cross section found by dividing by the total width of stream, or

$$Vm = \frac{\text{Vel. Area}}{1},$$

from which

$$Q = Vm \times \text{Sub area}.$$



GRAPHICAL REPRESENTATION OF METHOD FOR DETERMINING STREAM DISCHARGES.

GAGING OF ROGUE RIVER, ORE., AT GRANT'S PASS, JULY 30, 1904.

Station.	Rev. P. M.	Rev. P. S.	Vel.	Vel. Area.	Dist.	Depth.	Sub. Area.
				2.5	5.0	4.7	25.2
1	24	0.40	0.99	13.5	14.18	5.4	87.2
2	22	0.37	0.92	17.7	17.25	6.9	119.0
3	28	0.47	1.13	20.3	17.25	6.9	113.7
4	30	0.50	1.22	20.4	17.25	6.3	104.3
5	28	0.47	1.13	18.7	17.25	5.8	101.7
6	25	0.42	1.02	20.0	17.25	6.0	103.5
7	32	0.53	1.29	23.6	17.25	6.0	97.5
8	36	0.60	1.45	23.5	17.25	5.3	90.6
9	31	0.52	1.27	24.7	17.25	5.2	88.0
10	40	0.66	1.60	23.5	17.25	5.0	93.2
11	28	0.47	1.13	20.0	17.25	5.8	82.3
12	29	0.48	1.20	22.8	17.25	4.3 4.7	85.4
13	36	0.60	1.45	22.2	17.25	5.2	90.6
14	28	0.47	1.13	21.9	17.25	5.3	92.3
15	35	0.58	1.41	23.3	17.25	5.4	95.8
16	32	0.53	1.29	21.6	17.25	5.7	98.3
17	30	0.50	1.22	18.5	17.25	5.7	100.8
18	22	0.37	0.92	17.1	17.25	6.0	94.0
19	26	0.43	1.06	10.9	11.00	4.9	50.0
20	22	0.37	0.92	2.4	5.25	4.2 2.7	18.1
				389.1	328.68		1,831.5

$$\text{Mean Velocity} = \frac{389.1}{328.68} = 1.184 \text{ ft.}$$

Discharge = Mean Vel. × Sub. Area = 2.168 cu. ft.

*Chamber of Commerce, Portland, Ore.

A PECULIAR FLY-WHEEL ACCIDENT is described in the April "Bulletin" of the Fidelity & Casualty Co. as follows:

A fly-wheel in the Jessup and Moore Paper Mills, at Providence, Md., exploded on March 10 in a peculiar way.

The wheel was a belt-wheel, 16 ft. in diameter and 31 in. face. It weighed about 16,000 lbs., and was on an engine of the Corliss type.

It was made in halves, and had the usual bolted and flanged rim-joints located midway between the arms. Both of the rim-joints, together with a section of the rim extending nearly to each of the adjacent arms, were thrown out and hurled across the engine-room. The rest of the wheel remained intact, and continued to revolve until steam was cut off at the boiler.

The joints themselves were not pulled apart. The pieces thrown out were of the same length, and similar in every respect even to the appearance of the fractures at their ends.

These fractures showed a discoloration extending over about half the area of each end. The discoloration was caused by oil that had worked in through unobserved cracks, developed, probably, several years previous to this accident.

The cracks were evidently produced by the throwing out of the heavy rim-joints under the action of centrifugal force. It indicates that the engine, on some previous occasion, ran away and cracked the rim; but that it was stopped before a complete rupture occurred. The engineer, however, can recall no occasion of this kind.

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Two papers reprinted on another page of this issue place clearly before the reader a summary of recent development in high-tension alternating-current railway work. They offer a hopeful outlook for the future of this means of transportation. Methods of overhead trolley line construction are exhibited which reveal full appreciation of the various requirements as to mechanical strength and durability sufficient to cope with heavy and high-speed traffic, as to freedom from interruption, safety and the like. All of the constructions shown contrast strongly with present and past practice in direct-current trolley work, in which latter, as Mr. Varney says, "the insulation is made only good enough, and the supporting structure only strong enough, to keep the cars running by the aid of an efficient repair department."

Whether this characterization is accurate or not, it will be conceded by most men that present forms of overhead work will never do for high-speed high-potential traction, unless they be elaborated in details to an extent amounting to wholly new design.

At the same time the fact is clear that, provided a fully satisfactory conductor and collector construction is available, the high-tension alternating-current railway is technically and financially possible, and will be a large—possibly a predominating—element in future electric traction work. The wholly successful operation of the Valtellina Railway and other European high-tension polyphase lines for several years, and the promised success of the various single-phase railways in this country and abroad which have been put into service during the last six months, are sufficient evidence that no unsolved technical difficulties exist. The financial phase has been calculated and recalculated often enough to show that, with commercial production of the required apparatus, alternating-current operation merits careful consideration in competition with direct current, when any specific case of electric traction equipment is to be studied. The former can show results at least as good as those realized from the direct-current system, on any and all interurban railways (other than country tramways) yet built.

It is true that it has not yet been shown by any definite example that the limits of distance are extended by alternating current traction. But, for the matter of that, it has not yet been shown that the standard 600-volt direct-current traction system has any limit of distance, provided the available traffic be sufficient to maintain a purely passenger railway. Lines up to 100 miles long already exist, and they do not appear to be materially handicapped by the necessity of operating rotary converters at the substations in addition to transformers. These lines, moreover, while they are in favorable territory, are by no means in the best territory that the country affords. Some of the most promising routes for interurban passenger railways, routes connecting very large cities lying only a short distance apart, have through obstacles of various kinds, legislative and others, remained closed paths for the electric high-speed railway.

But precisely on these heavy-traffic routes, and on the directly-allied main-line railways—steam railways "electrified"—conditions appear that strongly favor the high-tension railway. When trains of any considerable size and weight have to be moved, the units of power concerned become very considerable. The Valtellina Railway uses electric locomotives rated at 900-HP. capacity, but often taxed to 1,200 and even 1,500 HP. under adverse conditions. The Baltimore & Ohio Ry. tunnel locomotives (two 80-ton sections coupled together) exert a normal power of 1,800 HP. The new electric locomotives being built for the New York Central & Hudson River Railroad have a maximum capacity of 3,000 HP. In discussing heavy-traffic electric railways these figures must be kept within view as ultimate factors in the problem. They mean correspondingly heavy currents to be drawn, whether by one or by several collectors, yet from a single conductor. With a line potential of 600 volts, a current of 1,000 amperes would be involved by even the smallest case on the horizon of future work, rising rapidly to 2,000, and even 4,000 amperes. Higher potentials relieve the situation. With 3,000-volt alternating current, the 1,000 amperes would be reduced to a current no higher than that drawn by a single street car on a direct-current line. With 15,000 volts—the potential suggested by Mr. Damon for main-line work—the New York Central locomotive would draw less current from the conductor than a street car requires.

The question of third-rail or overhead conductor comes most strongly to the front at this point. Is the heavy electric railway work of the future to use a surface or an aerial conductor? Electric railway engineers are strongly divided in their opinions. Some hold that the third-rail has first call for consideration in heavy electric traction, while others emphatically declare that no surface conductor can meet the conditions of service, whether low or high voltages are used, but especially with high voltages.

Pending the clearing of opinion, work is being done on both sides. The New York Central terminal work will be equipped, it is promised, with a form of third-rail that may be operated at relatively high voltages. Overhead conductors, on the other hand, have been developed in various places and by various interests, as exhibited in the papers of Mr. Damon and Mr. Varney. The longitudinal suspension-wire construction has been employed with very fruitful results, most thoroughly and mechanically, perhaps, in the system described by Mr. Varney. The insulator problem, one of the difficult points of the subject, has been neatly solved by the use of insulating sleeves supported in their full length, an expedient made possible only by the suspension-wire system. On the whole, sufficient is shown to warrant the conclusion that the overhead conducting system has been brought appreciably nearer to its ideal form; a continuously supported aerial conductor of large section —an overhead third-rail.

A significant feature of the two papers in question is their showing that high-tension alternating-current railway work will involve more expensive line construction than present direct-current practice calls for. Some time ago Mr. B. J. Arnold, in speaking of his design of a high-tension single-phase traction system for the Lansing, St. Johns & St. Louis Ry. (Michigan), said that he was led to the use of high-tension current by the absolute need, in that instance, of most economical construction. A similar thought is expressed in Mr. Damon's paper, where he speaks of the demand for a system "so simple in its requirements that it can be built and equipped complete for less than $15,000 per mile, and operated on a basis equally economical. This . . . means a trolley pressure as high as possible . . . etc., This seeking for cheapened line-construction by the use of alternating current finds no support in the forms of overhead work here described. On the contrary, it would seem that high-tension trolley construction must of necessity be more expensive than that for low pressures, the more so as it will no longer be safe to run in country highways and village streets. Nothing is brought out that carries us any nearer to the cheap light-traffic farmer's railway than the direct-current type of trolley road.

A correspondent inquires what is the usual practice in the measurement of sewers for a contractor's final estimate. Should the lineal feet of sewer be measured on a horizontal plane, or should the lineal feet on a slope be used? It is argued on the one hand that the contractor has had to purchase pipe to cover the entire distance measured on a slope, and on the other hand that since the vertical depth of ditch is measured, if the distance is measured on a slope, the contractor will be paid for more excavation than he has really accomplished.

A very common clause relating to measurement is as follows:

> Measurements of the sewers will be taken from the center of the uppermost flush tank or manhole on each line to the center of the manhole at its junction with a main or lateral, or to the center line of such main or lateral at the junction, including all branches or manholes.

This clause is by no means free from ambiguity, for it can be argued that measuring from center to center of manholes may be properly done on a horizontal plane, the word "center" applying to a central, vertical axis and not to a mathematical point.

Sewer grades are usually so slight that it makes very little difference whether the measurement is made horizontally or with the grade. Thus, the difference between the two methods of measurement is only 0.02 ft. per 100 ft. on a 2% grade; 0.12 ft. on a 5% grade; 0.32 ft. on an 8% grade; and 0.5 ft. on a 10% grade. With grades of 8% or more, the method of measurement assumes importance, and the specification should be made clear beyond dispute on this point.

As bearing upon this point, the following clause taken from the specification above quoted may be of interest:

> The lead service pipe shall be measured from the center of the water main to the center of the flush tank along the center line of the ditch in which the pipe is laid.

While this clause is not altogether free from ambiguity, it appears to indicate an intention to measure along the center line of the lead pipe, and not along a horizontal plane between two vertical axes.

We shall be glad to hear from any of our readers upon the general practice in the matter of sewer-pipe measurements.

THE LAND DISPOSAL OF GARBAGE: AN OPPORTUNITY FOR ENGINEERS AND CONTRACTORS.

We briefly described in our issue of Feb. 2 the method of garbage disposal which has recently been put in operation at St. Louis. That city's garbage is being carried by boat to an island in the Mississippi River, 20 miles below St. Louis, where it is plowed into the land. By the adoption of this method the city is saving largely compared with the amount it formerly paid a private company for the treatment of garbage by the reduction process.

We believe that this experiment at St. Louis might well lead engineers and sanitarians to give more attention to the possibilities in the treatment of garbage by burial on agricultural lands. The system is already in quite extensive use, but is generally regarded as more or less of a makeshift, as indeed it is when conducted in the ordinary manner.

There is no reason, however, why labor-saving machinery and methods and intelligent supervision should not be applied to this as well as to any of the other systems of garbage disposal. It may be of interest to discuss briefly some of the possibilities of the system.

In the first place, it should be said that land burial properly carried out, should be and actually is a perfectly sanitary method of disposing of garbage, and is so recognized by the best sanitary authorities. We do not mean by this that garbage could be buried without complaint on land in a thickly built-up suburb. What we mean is that on farming lands remote from dwellings, garbage should be buried with no more sanitary objection than the handling of stable manure; and that when garbage is once properly buried on a tract of land, there should be no further offense from it. It will be gradually reduced by the slow processes of inodorous decay into suitable food for plants, and should leave the land much more valuable for agricultural purposes than before the garbage was applied.

To make land burial of garbage successful, however, something more systematic than the ordinary method of plowing it into the land is needed. The garbage should all be buried under a depth of at least six inches of fresh earth. If it is thus effectively buried, there is no reason why a much larger quantity of garbage might not be applied to a given area than has ever, so far as we know, been attempted. This is an important point, since on it the possibilities in garbage disposal by burial very largely depends. A little computation will show this. Suppose that by covering thoroughly with at least 6 ins. of earth, we can bury 9 ins. depth of garbage over the entire area of a field. Then an acre of ground will take 32,670 cu. ft. of garbage, or say 600 tons. If we take the average annual production of garbage per 1,000 inhabitants at 75 tons, a city of 25,000 inhabitants would produce 1,875 tons of garbage per annum, which could be all disposed of on a field a little over three acres in extent; or a tract of 30 acres would last such a city for ten years.

Doubtless some one will question whether so large an amount of garbage could be buried on land without offense; but a study of the nitrifying and purifying properties of fresh soil and of the composition of garbage should reassure one. It is well known that even such highly offensive substances as spoiled meat and the bodies of dead animals, when buried in the earth, with a cover of only a few inches of fresh soil, give off no offensive odor and are gradually resolved into their original elements without offense. Garbage, however, contains only a very small percentage of animal refuse. In a cubic foot of average garbage from an American city, from 70 to 80% is water, and when this is removed it will be found that the bulk of the remainder is vegetable matter, rubbish and bones, leaving not more than 3 to 4%, probably, of grease and animal matter. Now it will certainly be conceded that all the vegetable matter in garbage will decay without offense under a very slight cover of earth, and it will be seen that the actual quantity of animal matter buried in the soil, even if we applied garbage to a depth as great as a foot, would be no considerable amount. It will also be evident when the actual composition of garbage is considered, that while 600 tons to the acre may seem like a large amount to apply to land, it is so largely composed of water and vegetable matter that it cannot possibly injure the land for agriculture by over-fertilization, especially if it is buried under a depth of at least six inches of earth.

It will be readily perceived that the possibility of applying a very large amount of garbage to a given area of land without offense would place land disposal of garbage on an entirely different basis from its present status. That this can be done and done successfully there seems every reason to believe; and much more might be said in support of the proposition did space permit. We turn now, however, to the practical problem of how to apply the garbage to the land. At present this is done in the crudest sort of a way, and solely by hand or horse labor, so far as we are aware. At the island where St. Louis deposits its garbage, we are told, the garbage as brought to the island is spread over the ground, where a drove of a thousand hogs root it over, and eat what they choose, and the rest, constituting a layer of about four inches depth, is plowed into the soil.

This is certainly not a pleasant picture, nor is it one calculated to impress a person with the advantages of this method of garbage disposal, even if the hogs were left out. But so long as it is attempted to bury garbage by merely plowing it into the ground, nothing very different from this can be done. The garbage has to be spread out more or less, and is bound to be more or less imperfectly and unevenly buried, and will be covered for the most part with a very shallow depth of soil.

Suppose now, instead of following the old plan of spreading the garbage broadcast over the surface of the field, we were to adopt the totally different plan of placing the garbage in trenches. Suppose the tract on which the garbage is to be placed is say 500 ft. in length and we begin by opening a trench a foot deep and 2 ft. to 3 ft. wide along one side. The garbage teams discharge their loads into this trench, filling it to an average depth, say, of 9 ins. A single trench across the field would then accommodate some 20 tons. To cover this garbage we will excavate another trench alongside the first one, and turn the dirt over onto the garbage in the first trench. The principle of the operation is exactly the same as if we placed garbage in the furrow left by a plow going across the field and covered it with the plow as it made the return furrow; but the important difference is that instead of turning a furrow with an ordinary plow, only 6 ins. deep and perhaps 10 ins. wide, we will make a furrow two to three times as deep and two to three times as wide. By this simple change we will cover the garbage more deeply and more thoroughly, and are enabled to dispose of three or four times as much on the same area of land as is ordinarily done.

And now how will we turn the furrow? The first expedient that suggests itself is simply a mammoth plow, hauled back and forth across the field by a wire cable, as is actually done in steam plowing machinery. But a plow would not readily give the lateral displacement that is needed, and the actual work involved in moving a strip of earth a short distance laterally is so small in amount as to be well within the capacity of a pair of horses. The best machine, apparently, would be something on the principle of a miniature road machine, small enough for one pair of horses to draw and at each trip across the field taking a narrow slice out of the trench and discharging it at a point about 3 ft. to one side.

Of course other types of machines might be devised and a steam or gasoline engine might be used; but the work to be actually done is so small in amount that given the right machine to do it, horse power would almost certainly be cheaper than anything else.

It is safe to say that there are half a dozen builders of earth moving machinery who would furnish a satisfactory machine to a contractor's order to move earth in the way specified above, and it will certainly be agreed that the work of making successive trenches and covering the garbage deposited therein, if done by machinery in this way, could be carried out at very small cost.

But now we anticipate that the reader who has followed the project thus far will perceive one great difficulty in the way. What is to be done in the winter months when the ground is frozen hard? In most cities of the United States there are from two to five months of the winter season when the earth is frozen as hard as a rock, and a city's garbage must be taken care of then as much as in summer. What would a city adopting land disposal of garbage do in the winter months?

At first sight the difficulty may seem insurmountable; but it is really not at all serious. In the fall before the ground freezes, a number of trenches would be opened across the disposal field, sufficient to take care of the garbage for the whole winter. For example, a city of 25,000 inhabitants, producing say 2,000 tons of garbage a year, or not more than 600 tons in the winter months, would require 30 trenches across a 500-ft. field to be made in the fall to last through the winter. As soon as the ground freezes, the covering the garbage in the ordinary way would cease and the garbage would simply be deposited in the trenches (any snow being first cleared out) and left there to freeze, and while frozen, it would be entirely inoffensive. To avoid all complaint from the giving off of odors during thaws, etc., however, suppose we open a borrow-pit near the disposal field, and at intervals of once a week or so cover the newly-deposited garbage with an inch or two of earth. This will be sufficient to prevent any nuisance whatever until the ground has so thawed in the spring, that the garbage can be covered to the usual depth in the regular way. The actual amount of borrow-pit excavation required would be very small, as a little computation will show. Our estimate above was 30 trenches, each 2½ ft. wide and 500 ft. long. To cover the contents of these trenches 1 in. deep would require only a little over 100 cu. yds of earth. If the winter garbage were covered with two or three inches depth of earth instead of a single inch, the cost of excavating and spreading the earth would still be so small as to constitute no objection to the plan.

From the above brief outline it will doubtless be conceded that land disposal of garbage is practicable in winter as well as summer. Now let us see what are the advantages and what the limitations of the whole scheme as compared with the two other sanitary systems of garbage disposal now in use, viz., cremation and reduction.

The first limitation of the land disposal system is the possibility of securing suitable land within a reasonable distance. Sandy soil naturally underdrained would be the ideal land. On a stiff clay soil or a swampy tract it would be difficult to carry out the system, both for sanitary reasons and because of the difficulty of working the land and carting across it in wet weather.

The larger cities would find difficulty, often, on account of the distance the garbage would have to be transported to get beyond the region of suburban residence. There are possibilities, however, in the use of water or rail transportation to overcome this difficulty. As noted above, St. Louis is finding great advantage in the use of barge transportation down the Mississippi through the delivery of garbage at several different points on the river front instead of being obliged to cart it all to one central disposal plant. Many other cities are located where cheap transportation by river or sea could be made use of. Even in New York City it would be entirely feasible to transport garbage up the Sound and use it to fertilize barren sandy tracts on Long Island.

There is admittedly difficulty, however, where garbage is handled in bulk and has to be transferred from barges to cars or carts for hauling to the disposal site. This difficulty would largely disappear, however, wherever the admirable can system of garbage handling, described elsewhere in this issue, is adopted. By this plan the filled garbage cans could be transferred from the collecting wagons to boats, freight cars or trolley cars, carried to the disposal site and there transhipped wholly without offence and with a very moderate amount of labor.

If this can system of handling garbage were used, we see no reason why a garbage disposal field should be any more objectionable in a neighborhood than a garbage crematory or a garbage reduction plant. Indeed, a disposal field would probably be much less offensive than either of the other systems.

The land disposal system, we believe, would present greatest advantages in the case of the smaller cities of say 10,000 to 50,000 population, at most such cities it is possible to find tracts of farming land which would be available for such a purpose, not more than three or four miles away, so that the distance of haul would be no serious obstacle. It is in cities of this size, moreover, that other methods of garbage disposal are less readily adopted. The amount of garbage to be treated in the smaller cities is not enough to make a reduction plant commercially possible, and the operation of a garbage crematory of a size suited to a city of 10,000 costs much more in proportion than for one of 50,000.

The land system of disposal, moreover, is simpler by far to operate than any other. It requires

expensive skilled labor; and there is nothing to break down or get out of order and upset the whole system of garbage collection. It can be carried out by local contractors and is open to free competition; or it can be conducted by the city itself, with no considerable investment in plant and apparatus.

From the economic point of view, it saves from destruction all the fertilizing elements in the garbage, and would enable barren sandy wastes to be converted into market gardens. Doubtless the objection will be raised by some amateur students of the refuse disposal question that cremation offers the possibility of utilizing the heat of the refuse for steam-making purposes. It is hardly necessary to say to our readers that garbage proper, such as we are considering here, is not now and is never likely to be, a fuel of any commercial value. Other rubbish, waste paper, etc., can, indeed, be sent to a crematory along with garbage, and if the plant is managed with unusual efficiency the whole may be burned without the use of any additional fuel. To expect to get any considerable income from the heat developed by burning garbage in any American city, however, is about as chimerical as the prospect of getting gold from sea water.

In the heading of this article we have referred to the land disposal system of garbage treatment as an opportunity for engineers and contractors. There are probably not a hundred cities in the United States that have to-day a sanitary, efficient and thoroughly satisfactory system of garbage disposal; but the demand that this condition shall be remedied is growing more and more insistent. Cities and towns all over the country are looking into the question of the sanitary disposal of refuse and are ready to give a favorable hearing to any system which can be shown to be unobjectionable from a sanitary point of view, and which will not involve such expense to instal and operate as a reduction or cremation plant.

The engineer or contractor, in a city where local conditions make land disposal feasible, who will work out the details of such a system as we have outlined, secure options on the necessary land and take a contract to carry out the work, and who will give intelligent supervision to the installation and operation of the system, should be able to accomplish much for sanitary betterment and to make a good profit on the enterprise.

LETTERS TO THE EDITOR.

Concrete Surfaces Between Tide Levels.

Sir: "A Maritime Reader," in your issue of March 30, referring to my remarks in your issue of March 2, 1905, regarding concrete *surfaces* between high and low water mark in ocean tidal waters, says: "No doubt many cases have been found in which such is the result."

I wish to say that it is to *some* of these cases that I had reference, and to add further that a close examination of the concrete above and below the water lines in these particular cases shows nothing which would indicate any fault in the composition of or the method of placing the concrete. The remark had reference to *surfaces* only, and not to the concrete body as a whole, and had no reference whatever to any of the 320 highway bridges mentioned by "A Maritime Reader."

Yours very truly,
Wm. B. MacKenzie.

Moncton, N. B., March 31, 1905.

A Millwright's Inch of Water.

Sir: In your issue of March 30, F. H. Shaw asks for "information as to the methods of measuring water by 'Millwrights' " fifty years ago. Square inches, with them, meant the square inches of the contracted vein. In other words, if the vent upon water wheels was said to be "2,878½ inches of water" the millwright would assume that these figures (square inches) were 62% of the actual area in square inches of the discharge orifices of the wheel.

Yours truly,
Asa M. Swain.

223 School St., Lowell, Mass., March 31, 1905.

(Evidently as the head was left out of account, the "millwright's inch" was not a unit of power. In the case cited by our correspondent last week, however, the term was used in a deed and referred to a particular power site, where the head of course was fixed and no uncertainty would be involved.—Ed.)

The First Award of the John Fritz Medal.

Sir: The first award of the John Fritz Medal, which was established by the professional associates and friends of John Fritz, of Bethlehem, Pa., on Aug. 21, 1902, his eightieth birthday, to perpetuate the memory of his achievements in industrial progress, has been awarded to Lord Kelvin.

This award was made by the following board selected for the purpose:

From the membership of the American Society of Civil Engineers: Robert Moore, Alfred Noble, Chas. Warren Hunt, Chas. Hermany.

From the membership of the American Institute of Mining Engineers: E. G. Spilsbury, James Douglas, Charles Kirchhoff, E. E. Olcott.

From the membership of the American Society of Mechanical Engineers: John E. Sweet, Robert W. Hunt, Samuel T. Wellman, James M. Dodge.

From the membership of the American Institute of Electrical Engineers: Carl Hering, Charles P. Steinmetz, Charles F. Scott, B. J. Arnold.

The medal is of gold, of value of about $100, and with it is presented a certificate of the award. The medal was awarded to Lord Kelvin for "Cable Telegraphy and Other General Scientific Achievements."

Yours respectfully,
Chas. Warren Hunt,
Secretary John Fritz Medal Board.

220 West 57th St., New York, March 31, 1905.

The Removal of the Panama Canal Commission.

Sir: Yesterday's papers brought the strenuous news that the members of the Panama Canal Commission were asked to tender their resignations. Men acknowledged to be of the highest engineering attainments, absolutely innocent of any dishonorable motives, striving to do their utmost for the best interests of the government, removed with barely a notice for—we must assume—reasons of non-success "in the eyes of the powers that be!"

Have these powers ever realized that in such important undertakings as the canal construction, lengthy investigations and studies, accurate planning of the various schemes, description and estimates, choice of working plant, material and labor, and many other factors require much time and money? How can the tributaries to the Chagres and the Rio Grande, during flood stage, be taken care of without thoroughly studying the possible methods of constructing an auxiliary canal on each side of the main canal bed at high elevations above the latter, on what may be termed shelves along the main banks? How will human ingenuity prevent the water courses on said shelves from breaking through their banks, or finding their way through and into the main canal, filling the latter with mud, silt and stone? How can a secure foundation for the several proposed high dams be obtained and the tunnel problem of diverting the upper Chagres waters from the Atlantic into the Pacific Ocean be solved? How is the steam shoveling to be done, when depths are reached in the Culebra cut over 200 ft. below the divide, where a flow of water must be encountered which, with the most powerful pumps at work, will drown boiler, engine, and pumps?

Leave sanitary conditions out of the question. These men have done all they could do and all anybody else will do or has done, whether French or American; but they are not given a chance to reap their well merited harvest, to enjoy a reward for their difficult studies, for the gift of their experience and good judgment, nor are their labors even appreciated.

Who will warrant the selection of new men in the commission of engineering and management to be superior to the one just dismissed? If selection was made a year ago of the best material the country possessed, as we all believed, why should our opinion of those men be changed to-day?

Respectfully,
H. Von Bayer,
C. E., Bureau of Fisheries.

Washington, D. C., March 31, 1905.

The Durability of the Vanes in Westinghouse-Parsons Steam Turbines.

Sir: There has recently been brought to our attention from numerous sources a report upon the alleged short life of the vanes in steam turbines, stated to have been inspired by a European engine builder. The sole evidence rests upon photographs of turbine vanes purported to have worn out with less than one year's service. This report bears all the earmarks of misinformation, if not of malicious falsehood, especially as similar photographs have been covertly circulated in this country as representing the experience in various American turbine plants. We therefore ask the courtesy of your columns for a brief statement of facts, and are content to leave to the good judgment of your readers the conclusions to be drawn therefrom.

The text of our argument we find in the following passage: "As to the cost of maintenance and repairs, it is claimed that there is an enormous wear (meaning erosion) in the back of the turbine blades . . . . . ." Photographs of both convex and concave sides of a new and a damaged vane are shown. From a careful examination of these photographs we conclude either, First, that the supposed erosion is probably due entirely to an accident in which the blade in question had been badly damaged by the flying particles, but not entirely broken off; or, second, that a new blade has been deliberately injured for illustrative purposes; or, third, that it has been in a class of service of the severity of which we have no conception.

The photographs in question show that both edges of the blade have been curled over, so that in the position in which the photograph is taken a considerable portion of metal appears to have been eaten away. There is also conspicuous evidence of the indentations of a round-nosed instrument on one of the damaged edges and of a chisel upon the other. Such injury is manifestly not due to normal wear, as the innocent looking title would lead one to believe: "Same bucket after having been in use less than one year."

A skillful photographer can, by adjusting lights, shades and focus, create most convincing effects. To illustrate, we have photographed a turbine blade, Fig. 1 herewith, which was taken out of an experimental machine in which several rows of vanes had been damaged, due to accidental distortion of the casing. This photograph bears a striking resemblance to those referred to above and shows how easily a false impression may be created. You will observe that this blade bears strong evidence of erosion upon the back, whereas it was in fact a new vane damaged in the manner shown simply by bombardment of small broken particles of other vanes. If the photograph had been taken slightly out of focus, the edge shown curled over, in the view of the concave surface, would have appeared to be badly eaten away. The concave surface is of course intact.

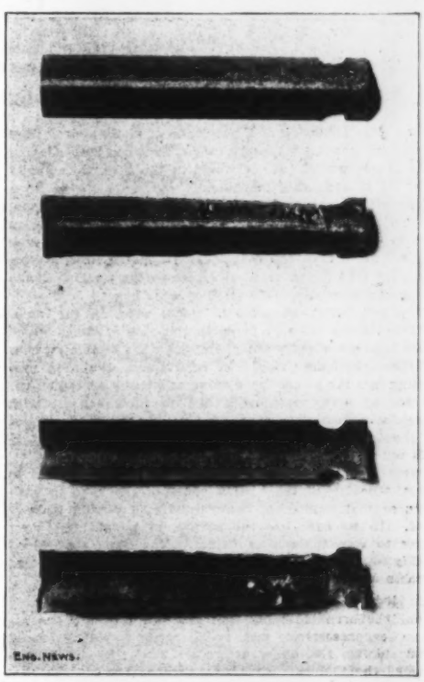

Fig. 1. New and Damaged Blades from Westinghouse-Parsons Steam Turbine.

Damaged blade, apparently injured by erosion; was in reality damaged as the result of distortion of the turbine-casing.

In support of our contention that steam erosion in the Parsons type of turbine is quite negligible owing to the low steam velocities employed, we have recently photographed the interior of the first steam turbine put into practical use in America and the first turbine built by us for commercial service. This machine was installed in 1899, and together with the three units installed soon after, has since been in continuous service upon a 24-hour factory load. Fig. 2 shows the upper half of the stator; Fig. 3 the upper half of the rotor; Figs. 4 and 5 show closer views of stator and rotor, respectively. In the last two views a position was chosen looking directly along the cutting edges of the vanes to show their condition after over five years' continuous service.

In order to exhibit this still more clearly in detail, two vanes were deliberately broken out of the eighth and twelfth rows, respectively, of the low pressure barrel where the greatest quantity of moisture occurs and where erosion would, if at all, be expected. These are shown in Figs. 6 and 7. Although reproduced as sharply as possible, the old vanes are even in better condition than they appear and their metallic surfaces have retained the original polish of new vanes as they come from the drawing machine. Fig. 8 shows one of these specimens

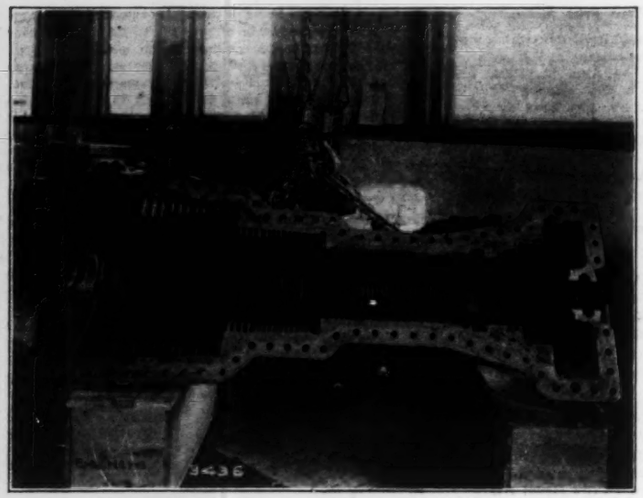

Fig. 2. Upper Half of Stator.

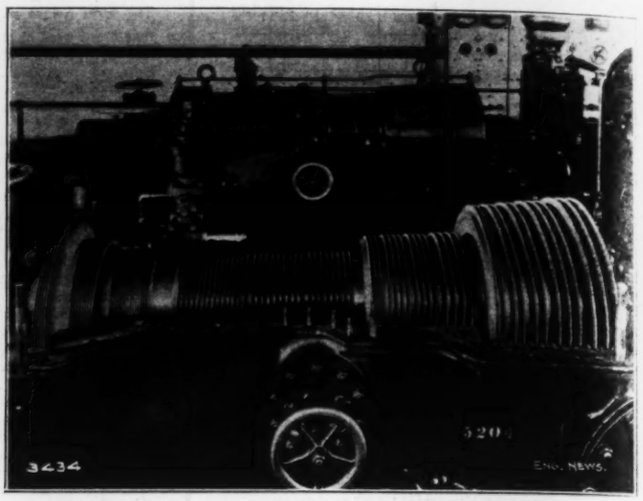

Fig. 3. Upper Half of Rotor.

(From the first Westinghouse-Parsons steam-turbine built and put into commercial use in the United States. Installed in 1899; has been in continuous 24-hour factory service ever since.)

FIGS. 2 AND 3. INTERIOR OF WESTINGHOUSE-PARSONS STEAM TURBINE AFTER FIVE AND ONE-HALF YEARS' CONTINUOUS SERVICE.

set on edge alongside of a new vane of similar size. The end of the new vane appears rough, as it has been sheared off and not ground true as would be the case when finally inserted in a finished machine.

Three facts must be apparent from these photographs: (1) That the old vane has retained its full cross-section and hence its full mechanical strength; (2) that the vane angles, and hence the efficiency, are unimpaired in service; (3) that the surfaces along which the working steam passes have not lost their original smoothness.

The only effect traceable to steam wear on the vanes of this turbine is to be found in the case of vanes which have been set slightly out of line with the remaining ones of their particular ring. In such cases, the area projecting into the steam space becomes slightly scored on the advancing side, presumably due to their contact with particles of moisture coursing through the lower stages of the turbine during light loads when their velocity in this region is probably somewhat less normal. This effect, however, but occasionally develops and simply results in the sharpening of the cutting edges of the vane to such fineness that a piece of heavy cord may readily be severed. In no case has the section of metal been worn away to any appreciable extent. The vane reproduced in Fig. 6 was slightly out of line and shows this effect as much as any other in the turbine.

In judging the results obtained from this turbine it should be borne in mind that the steam supply has always been excessively wet, owing partly to a long run of steam piping. No superheaters are used. On several occasions the turbines have been checked considerably below their normal speed from the effects of slugs of water passing through them. It also frequently occurs that creek water has to be put into the boilers owing to the failure of city water supply. This water is at all times extremely acid and very impure. In fact it has been necessary to coat the outer surface of the dummy pistons with white lead to prevent their corrosion from this acid water. Owing to the accumulation of sediment, the turbines have to be frequently cleaned by air blast, as the steam velocities are not sufficient to keep the passages clear.

In conclusion it should be recalled that the turbine on exhibit represents the beginning of the present turbine industry in America. Its failure would have been even more conspicuous than has been its success. It is therefore reasonable to suppose that improved methods of manufacture and increased understanding of the turbine art should have resulted in an improved machine rather than the reverse.

Respectfully,

The Westinghouse Machine Company.

East Pittsburg, Pa., March 31, 1905.

Notes and Queries.

S. H. C. asks what is the best practice in designing the crown of a street having one curb 20 ins. higher than the other, roadway being 34 ft. wide. Is it preferable to use a half parabola draining to one side, or a circular section draining to both gutters?

In our issue of Feb. 9 we reprinted extracts from a paper by Mr. J. T. Richards, Chief Engineer of Maintenance of Way of the Pennsylvania R. R., before the Forestry Congress at Washington, describing the work of tree culture undertaken by the Pennsylvania R. R. In the April number of "Arboriculture" Mr. John P. Brown, of Connorsville, Ind., comments on Mr. Richards' paper and states that the ill success of that company with catalpa trees which were set out along its lines in Indiana 20 years ago was due to the fact that the trees were of the useless bignonioides species or else hybrids; that the trees were set in dense sod and were wholly neglected, and mutilated by telegraph linemen. Regarding the locust trees which the Pennsylvania is planting, Mr. Brown states that not over 200 trees per acre of sufficient size to furnish ties can be grown instead of the 400 trees per acre estimated by Mr. Richards.

THE NEW ISTHMIAN CANAL COMMISSION.

The executive order appointing a new Isthmian Canal Commission was made public on April 3. The new commission is made up as follows: Theodore P. Shonts, Chairman; Charles E. Magoon, Governor Canal Zone; John F. Wallace, Chief Engineer; Rear Admiral Mordecai T. Endicott,, U. S. N., Brigadier General Peter C. Hains, U. S. A., Colonel Oswald H. Ernst, Corps of Engineers, U. S. A., and Benjamin M. Harrod. Of these seven commissioners only one, Mr. Benjamin M. Harrod, M. Am. Soc. C. E., was a member of the first Commission.

The executive order appointing the new commission was based on the report of Secretary of War Wm. M. Taft, who visited the Isthmus and investigated the organization and progress of the canal work on behalf of President Roosevelt. Secretary Taft's recommendations were embodied in the following letter to the President:

In the matter of the reorganization of the machine by which the Panama Canal is to be built, I beg first to call your attention to the extreme importance of fixing a definite plan with respect to which you may feel reasonable certainty, first, that it can be practically executed,

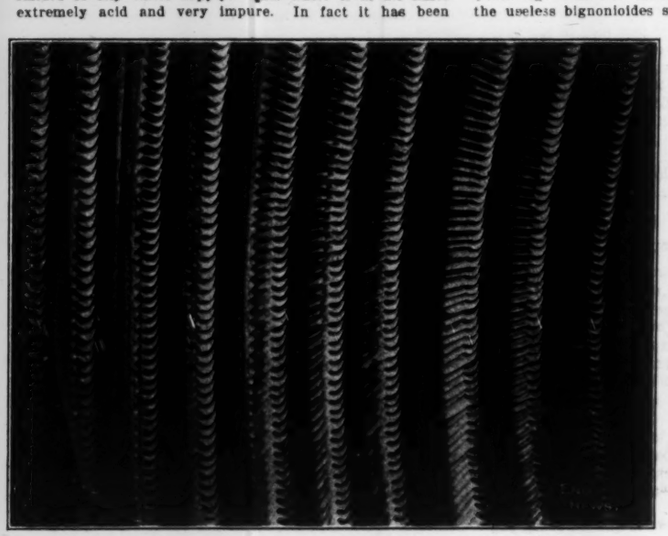

Fig. 4. Fixed Vanes.

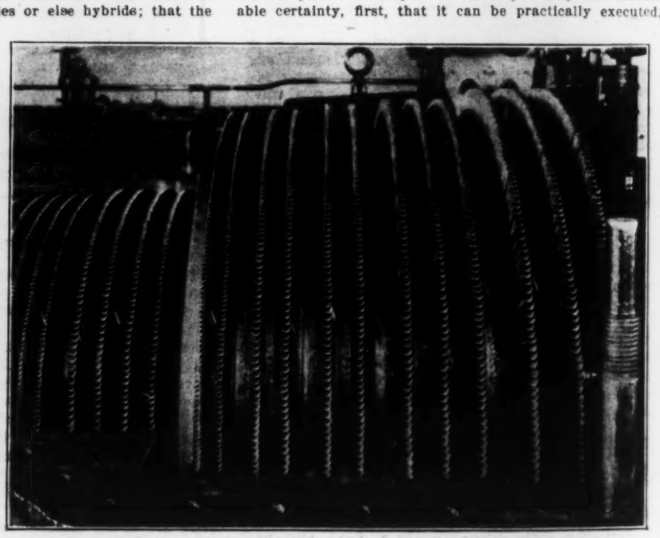

Fig. 5. Moving Vanes.

FIGS. 4 AND 5. DETAIL VIEWS OF VANES OF STEAM TURBINE AFTER FIVE AND ONE-HALF YEARS' SERVICE.

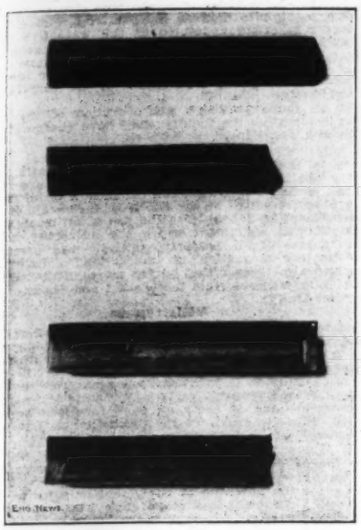

Fig. 6. Vane from Rotor, Eighth Row of Low-Pressure Barrel.

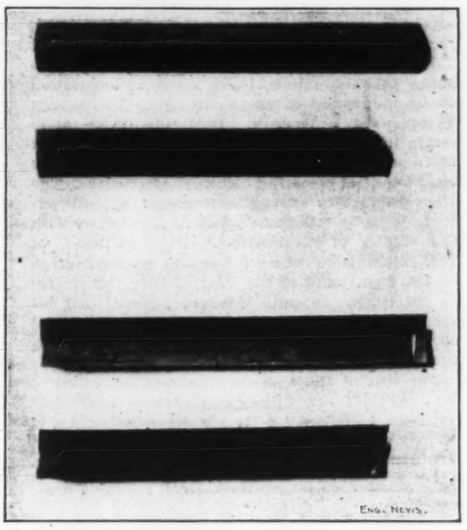

Fig. 7. Vane from Twelfth Row of Low-Pressure Barrel.

FICS. 6 AND 7. COMPARISON OF VANES OF WESTINGHOUSE-PARSONS STEAM TURBINE AFTER FIVE AND ONE-HALF YEARS' SERVICE WITH NEW VANES.

will result in a navigable canal, and, second, that this navigable canal will be the one best adapted to the demands which may be made upon it by the commerce of the world.

The act of Congress evidently contemplates a canal with locks, the cost of which shall be in the neighborhood of $200,000,000, including the money already expended. It is quite within the bounds of possibility that the best form of canal will be a sea-level canal, with a tidal lock only, at one end, and that the cost of it may exceed the $200,000,000 in the mind of Congress by at least $100,000,000 more.

The work of the engineering department of the present commission has been largely devoted to obtaining the data upon which the plan of the canal must be determined. These data include topographical measurements, borings, the character of the soil, the flow of water in the rivers—all stated with sufficient exactness to secure the closest calculations by experienced engineers, though not on the ground.

It is probable that within the next few months these data will have been so fully ascertained by the chief engineer, Mr. Wallace, and his assistants, that they may be submitted to a board of engineers of the highest standing for recommendation as to the best plan upon which to proceed with the work.

It also has been made apparent, by the reports of Mr. Wallace and the commission, that whatever plan is likely to be adopted, work of excavation and construction, which would have to be done under any plan, may proceed without waste of energy for a period quite long enough to enable you to decide which is the best plan.

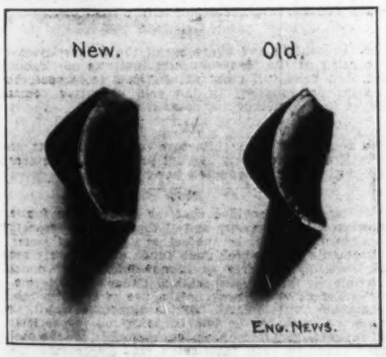

Fig. 8. Comparative End Views of New Vane and Vane After Five and One-Half Years' Service.

I suggest, therefore, that the first work to be done is the appointment of an advisory board of engineers—say seven or nine in number—to be selected from the engineers having especial knowledge of hydraulic engineering and canal construction, to whom with respect to the projected Panama Canal, both that obtained by the French engineers before our purchase of the plant and the data obtained by the Chief Engineer of the present Canal Commission, together with all projects suggested for the solution of the problem which the Canal Commission deems reasonably possible or practicable; that this advisory board be invited to Washington for the purpose of agreeing upon its recommendations in the premises, and that, if possible, such recommendations be made before the regular meeting of Congress in December; that the recommendations be submitted to the Canal Commission as then constituted, for its approval or modification; and, with the recommendation of the Canal Commission, be submitted to the President for his action and transmission to Congress.

As already suggested, this work of securing the best plan and its approval by Congress need not delay in any way the preliminary work adapted to any possible plan, or the highly critical work of sanitation, the extreme importance of which you have already emphasized in your previous instructions to the Canal Commission.

It is conceded, even by its own members, that the present commission has not so developed itself into an executive body as to give hope that it may be used successfully as an instrumentality for carrying on the immense executive burden involved in the construction of the canal, and it remains for the President, in the failure of Congress to act, to reorganize the commission, both by change in the personnel and by certain instructions as to its internal procedure and distribution of powers and authority, to secure greater rapidity and efficiency in the doing of the work.

The Secretary then states in detail his plan for the division of the work into departments and the reasons therefor, all of which details are accepted and promulgated in the President's order. The letter ends as follows:

The change of headquarters and power from Washington to the Isthmus will doubtless require a radical change in the office of the Commission in Washington. I am quite sure that great economy and more satisfactory methods of accounting can be secured than now exist. Machinery for purchase of supplies and a force sufficient to maintain a duplicate set of accounts and the necessary correspondence must, of course, be maintained in Washington, but very little else is needed. But these changes may be safely left to the Commission and Executive Committee as newly constituted.

I beg to submit herewith the resignations of all the present canal commission, to take effect at your pleasure.

I respectfully recommend the appointment of a new commission and a designation of the Chairman of the commission, the Governor of the zone, and the chief engineer, and the issuing of an executive order embodying the recommendations herein.

The executive order of President Roosevelt is as follows:

The practical result of the operations of the Isthmian Canal Commission has not been satisfactory and requires a change in the personnel and in the instructions for guidance.

The commission will hold quarterly sessions the first of January, April, July and October of each year at the office of the Governor on the Isthmus of Panama, and will continue each session as long as public business may require. Further notice of such meetings shall not be necessary to their regularity. The commission may hold special sessions at the call of the chairman. Four members shall constitute a quorum, and the action of such majority shall be the action of the commission.

The commission, under the supervision and direction of the Secretary of War, and subject to the approval of the president, is charged with the general duty of the adoption of the plans for the construction and maintenance of the canal and with the execution of the work of the same; with the purchase and delivery of supplies, machinery, and necessary plant; the employment of the necessary officers, employes and laborers, and with the fixing of their salaries and wages; with the commercial operations of the Panama Railroad Company and its steamship line as common carriers; with the utilization of the railroad as a means of constructing the canal; with the making of contracts for construction and excavation, and with all other matters incident and necessary to the building of a waterway across the Isthmus of Panama as provided by the act of Congress of June 28, 1902.

For convenience, and to secure the uninterrupted course of the work, an Executive Committee of not less than three members of the commission shall be appointed by the commission to act in place of the commission during the intervals between the meetings of the commission and to report its doings in full to the commission at the next regular meeting. A minute of every transaction of the Executive Committee shall be made, and one copy of the minutes shall be forwarded to the Secretary of War and another transmitted for the consideration of the commission at its next meeting.

Regular meetings of the Executive Committe shall be held at the office of the Governor on the Isthmus of Panama at 10 o'clock in the forenoon on each Monday and Wednesday of every week, and further notice of such meetings shall not be necessary to their legality. A majority of their number shall constitute a quorum for the transaction of business at such meetings. The action of such majority shall be the action of the Executive Committee.

For the convenience of executing the work to be done, there shall be constituted three executive departments.

The head of the first department shall be the chairman of the commission, who shall have direct and immediate charge of:

(1) The fiscal affairs of the commission.

(2) The purchase and delivery of all materials and supplies.

(3) The accounts, bookkeeping, and audits.

(4) The commercial operations in the United States of the Panama Railroad and steamship lines.

(5) He shall have charge of the general concerns of the commission subject to the supervision and direction of the Secretary of War and shall perform such other duties as may be placed upon him from time to time by the Secretary of War.

The head of the Second Department shall be the Governor of the zone, with the duties and powers indicated in the executive order of May 9, 1904, which includes in general:

(1) The administration and enforcement of law in the zone.

(2) All matters of sanitation within the canal zone and also in the cities of Panama and Colon and the harbors, &c., so far as authorized by the decrees of Dec. 3, 1904, between the United States and the Republic of Panama relating thereto.

(3) The custody of all supplies needed for sanitary purposes, and such construction necessary for sanitary purposes as may be assigned to this department by the commission.

(4) Such other duties as he may be charged with from time to time by the Secretary of War.

(5) He shall reside on the Isthmus and devote his entire time to the service, except when granted leave of absence by the Secretary of War.

The head of the third department shall be the Chief Engineer. He shall have full charge on the Isthmus:

(1) Of all the actual work of construction carried on by the commission on the Isthmus;

(2) The custody of all the supplies and plant of the commission upon the Isthmus;

(3) The practical operation of the railroad on the Isthmus with the special view to its utilization in canal construction work.

(4) He shall reside on the Isthmus and devote his entire time to the service except when granted leave of absence by the Secretary of War.

All officers and employes shall be appointed and their salaries shall be fixed by the head of the department in which they are engaged. Their appointment and salary shall be subject to the approval either of the commission or, if the commission is not in session, of the executive committee. The employment of laborers, where the contract of employment is made in the United States or outside of the Isthmus, shall be negotiated and concluded by the Chairman of the commission, subject to the approval of the executive committee. When the employment of laborers is effected upon the Isthmus, it shall be conducted under the supervision of the chief engineer, subject to the approval of the executive committee.

Contracts for the purchase of supplies or for construc-

tion, involving an estimated expenditure exceeding $10,000, shall only be made after due public advertisement in newspapers of general circulation, and shall be awarded to the lowest responsible bidder, except in case of emergency, when with the approval of the Secretary of War, advertising may be dispensed with. In the making of contracts for supplies or construction involving an estimated expenditure of more than $1,000 and less than $10,000, competitive bids should be secured by invitation or advertisement whenever practicable.

As soon as practicable after the date of this order the Isthmian Canal Commission shall hold a session in Washington for the general purposes of organization under this order, and for the special purpose of fixing the number and character of officers and employees to serve in Washington in the work of the Commission.

In addition to the above order a statement was issued by the Secretary of War respecting the salaries of the new commissioners. This statement was as follows:

The President has made an order allowing a salary of $7,500, with traveling expenses, to each member of the commission, and to the chairman of the commission the additional compensation of $22,500; to the chief engineer the additional compensation of $17,500, and to the Governor of the zone the additional compensation of $10,000. The head of each department is allowed the use of a furnished house upon the isthmus and his traveling expenses when traveling on the business of the commission. The total is $102,500. The salaries and allowances under the former commission amounted to $120,000. The total compensation of the Governor of the zone and the chief engineer are in effect unchanged.

Professor William H. Burr and William Barclay Parsons, civil engineers, will be appointed as members of the consulting board of engineers.

The following are brief sketches of the careers of the new commissioners, compiled from the accounts published in the daily papers:

Mr. T. P. Shonts, the chairman of the commission, is 39 years old, a graduate of Monmouth College, Illinois, and a railway man of considerable experience. He is at present the President and General Manager of the Toledo, St. Louis & Western R. R.

Charles E. Magoon, who will be governor of the canal zone, at a salary of $17,500 a year, was the general counsel of the old commission. Before his appointment he was law officer of the Bureau of Insular Affairs at the War Department for five years. He is in his forty-fourth year, and was educated at the University of Nebraska.

John Findlay Wallace, who is to continue in service as chief engineer of the canal at $25,000 a year, is by profession a civil engineer and a railway manager. He is 53 years old and was educated at Monmouth College and Wooster University, having received the degree of Ph. D. and LL. D. from the latter. He has served in various railroad capacities, being general manager of the Illinois Central Railway when appointed to take charge of the canal construction.

Rear Admiral Mordecai Thomas Endicott has been the chief of the Department of Yards and Docks of the Navy Department since 1898. Born in 1844 in New Jersey, he was graduated at the Troy Polytechnic Institute in 1868. He became a civil engineer and entered the navy in 1874 in the same capacity, being on duty at various navy yards. He was a member of the Nicaragua Canal Commission in 1895, and a member of the Ordnance Board in 1897.

Brigadier-General Peter Conover Hains was born in Philadelphia in 1840. He was graduated at the West Point Military Academy in 1861, and served throughout the Civil War, being brevetted several times for gallantry. He has had charge of many important works of harbor defence and improvement. He served as a brigadier general of volunteers in the war with Spain, and saw service in Porto Rico. In 1897 he was appointed on the Nicaragua Canal Commission, and in 1899 on the Isthmian Canal Commission. In July of last year he was placed on the retired list of army officers.

Brigadier-General Oswald Herbert Ernst is a native of Ohio, and is in his 63d year. He left Harvard in 1860 to go to West Point, where he was graduated in 1864. His first government service was as assistant chief engineer of the Army of the Tennessee, with which he remained until the close of the Atlanta campaign. He was afterward engaged in works on the Pacific Coast and the deepening of the Galveston channel, was superintendent of the West Point Academy and served in the Spanish-American War. In 1899 he was appointed on the Isthmian Canal Commission. He was recently made a member of the joint international commission to study the effect on navigation of the Great Lakes of the changes expected to result from the completion of the deep waterway project.

Benjamin Morgan Harrod, the only member of the commission reappointed, is a civil engineer, who was graduated at Harvard in 1856. His home is in New Orleans, of which he has been city engineer, having charge of the construction of the drainage system of that city, and also chief engineer of the State. He has been a member of the Mississippi River Commission since 1879.

THE PROPOSED ALLIANCE OF HARVARD UNIVERSITY AND MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

For some time past Massachusetts Institute of Technology and Harvard University have been seriously considering the advisability of joining forces. On March 14, the executive committee of the governing board of the Institute of Technology submitted a proposed agreement to its corporation, and the same agreement will be submitted to the Harvard governing board for action, provided the Boston institution subscribes to it.

The agreement provides for an educational alliance between equals, there being no suggestion of an absorption of the Institute of Technology by Harvard University. Each institution is to retain its present organization and integrity, but there will be no longer any competition in the teaching of engineering and applied sciences. The Harvard faculty of engineering and applied sciences is to be retained, and is to join forces with the faculty of Technology. The Institute of Technology is to secure a site and erect buildings on the right bank of the Charles River, as nearly as practicable opposite Harvard Square. All degress in engineering are to be conferred by the corporation of Harvard University and the Institute, acting separately.

The text of the agreement is as follows:

PREAMBLE.

Harvard University and the Massachusetts Institute of Technology, being convinced, after a careful consideration of the conditions which affect the work of education in industrial science, that such work can be greatly advanced and enlarged by a cooperation of the two institutions, in order to secure mutual assistance, render possible a larger enterprise, promote economy, avoid duplication and competition, and give to the purpose of donors who have bestowed money in trust for that object a fuller accomplishment do make this agreement, which shall endure so long as it shall be found to serve, to the satisfaction of both institutions, the objects above declared. But, whereas the carrying out of such agreement will require the employment of the income of the funds which the university holds, or will hereafter hold in trust, and the university feels that faithfulness in the performance of these trusts which it has accepted is its first duty, to which all other considerations must yield, this agreement shall not go into effect until and unless the university shall have applied to the Supreme Judicial Court for instructions and the Court shall have made a decree that this agreement may be carried out without violation of its duties as a trustee and in accordance with law and equity.

I.

The organization of the university, the organization of the Institute, and the title of each to its property and funds shall remain unaffected by this agreement, as shall also the rights and duties of each in investing and managing its funds.

II.

The institution for the combined work of promoting and furnishing education in industrial science, which it is the object of this agreement to establish, shall retain the name of the Massachusetts Institute of Technology; it shall be under the direction of an executive committee, and the instruction therein shall be given by a faculty, which two bodies shall be constituted as herein below provided.

III.

The said executive committee shall consist of nine persons, to be designated by the Massachusetts Institute of Technology, of which two shall be the president of the corporation of the Institute and the treasurer of the Institute, and three shall be members of the corporation of the university.

Subject to the restrictions herein below expressed, the said executive committee shall have the general administration and superintendence of all matters concerning said combined work, including the appointment of officers of instruction and government, and of servants, the power to remove any of them, the fixing of their salaries, and the prescribing of their duties, the care of buildings, property, and equipment, the appropriation of money put at its disposal under his agreement, the fixing, collecting, and expending of students' fees, and the supervision and direction of the work of the faculty, these being substantially the powers now conferred on the executive committee of the Institute by its by-laws; it being, however, expressly provided that all appropriations from money furnished either by the university or by the Institute, and all proposed appointments or removals of officers whose salaries are to be paid therefrom, shall be submitted to the corporation concerned and approved by it before being finally adopted, it being understood that students' fees shall be deemed to be furnished by the Institute, and that no change shall be made in those fees without its approval.

The said executive committee shall keep records of its proceedings, and shall make reports to the corporation of the university and the corporation of the Institute annually, and at such other times as either corporation may request.

IV.

The president of the Institute for the time being shall be the president of the said executive committee, and shall preside at its meetings, when present. His salary, as fixed by the corporation of the Institute, shall be paid from the funds furnished by the Institute. He shall be the chairman of the faculty, shall have the superintendence of the several departments, and shall act as general executive and administrative officer subject to the direction and control of said executive committee. He shall annually make a report to the corporation of the university and to the corporation of the Institute. Whenever a person shall vacate the office of president of the Institute, he shall thereupon cease to be a member of the said executive committee.

V.

The treasurer of the Massachusetts Institute of Technology shall be ex-officio the treasurer of the said executive committee. He shall, as treasurer of the said executive committee, have charge of the funds put at the disposal of said committee, shall make such payments as the committee may authorize, shall keep accurate accounts of all money received and expended, and shall make report of his doings annually, or oftener if required, to the executive committee, and to the corporation of the university and to the corporation of the Institute.

VI.

The faculty shall consist of all the present professors, associate professors, and assistant professors of the Institute, and all professors, associate professors, and assistant professors of the university who now give courses of instruction leading to degrees in industrial science, and such officers hereafter appointed as said executive committee may designate. The present professors, associate professors, and assistant professors of the university aforesaid shall not be removed nor have their present salaries reduced without the consent of the corporation of the university.

Subject to the supervision and direction of the said executive committee, the faculty shall have charge of instruction and discipline.

VII.

Subject to the reservations hereinafter set forth, the university shall place at the disposal of said executive committee, as above provided, the net income of all funds which are now credited on its books to the credit of the Lawrence Scientific School, also the use of all machinery, instruments, and equipment which the university holds, and the income of all property which it may hereafter acquire for the promotion of instruction in industrial science, and also three-fifths, but no more, of the net income which may accrue from the bequest and devise of the late Gordon McKay.

VIII.

Subject to the reservation herein set forth, the Institute shall place at the disposal of the said executive committee the net income of all funds and the use of all property and equipment which the Institute may hold for the promotion of instruction in industrial science, reserving only such amounts and property as it may require to maintain its organization and to carry on such functions as may remain to it independently of the promotion of industrial science.

IX.

In so far as money contributed by either corporation under this agreement may be used by the said executive committee for the purchase of equipment or supplies, the title thereto shall be in the corporation whose money is appropriated therefor.

X.

The site of the institution shall be in Boston on the right bank of the Charles River, as nearly as practicable opposite to Harvard square, and the Massachusetts Institute of Technology shall there erect, furnish, and equip buildings having the capacity of at least its present buildings. But the Institute shall not be required to proceed with such purchase and construction until it shall have sold a sufficient part of the land which it now owns. Provided, however, that this agreement shall be avoided if at the end of four years from the time when this agreement goes into effect the Institute shall not have purchased said land and proceeded to a substantial extent with such construction.

XI.

Within three years after the Massachusetts Institute of Technology begins the construction of such new buildings, if the Institute is then prepared to give in its new location to the students of the Lawrence Scientific School all needed instruction in industrial science, the Lawrence Scientific School shall be discontinued as a separate school of industrial science so long as this agreement remains in force.

XII.

The degrees of bachelor, master, and doctor in science, so far as given in industrial science, and all degrees in engineering, together with the requirements of courses of study leading to these degrees, shall be within the province of the faculty, and these degrees shall be conferred by the corporations of the university and the Institute, acting separately.

XIII.

Male students in the Institute shall have the same privileges as students in Harvard University in the use of the playgrounds, museums, and libraries of the university.

Under regulations to be made by the two corporations, and on payment of proper fees, students of the Institute shall be admitted to courses of instruction and the use of laboratories of the university, outside of those pertaining to industrial science, and students of the university to the courses and use of laboratories of the Institute.

XIV.

The corporation and overseers of the university and the corporation of the Massachusetts Institute of Technology shall each have full right at all times to inspect the institution, and suggest to the said executive committee changes in the methods of management.

XV.

The department of architecture in the university and in the Institute respectively are not included in this arrangement, but remain unaffected hereby.

XVI.

It is expressly provided that, as regards the funds and property of the university and of the Institute respectively, this agreement shall be subject to any special terms and requirements upon which such funds and property may be held; and any property or funds which may be held at any time by either corporation under such terms and restrictions as would prevent the use of them in the precise manner contemplated by this agreement shall, nevertheless, be used by the two corporations respectively for the support, benefit or encouragement of the scheme agreed upon, in such manner as may be permissible and in accordance with the trusts upon which they may be held.

XVII.

The arrangement established by this agreement may be terminated at any time, either by the president and fellows of Harvard University, or by the corporation of the Massachusetts Institute of Technology, upon reasonable notice to the other corporation.

In the event of the termination of this agreement, the Massachusetts Institute of Technology must pay, at such prices and upon such terms as the parties may agree upon, and, if they cannot agree thereon, as may be fixed by arbitration (usual arbitration clause), for any buildings or fixtures upon said site, paid for with funds furnished by the university.

XVIII.

This agreement shall take effect when finally adopted and approved by the corporation and the overseers of the university and the corporation of the institute, and when and if a decree of the Supreme Judicial Court, as provided for in the preamble thereof, shall have been obtained.

NOTES FROM THE ENGINEERING SCHOOLS.

RENSSELAER POLYTECHNIC INSTITUTE.—In our issue of Mar. 23 the statement was made that the enrollment (306) of civil engineering students at Purdue University in 1903-4 was exceeded by one school only. Our attention is called to the fact that the enrollment of civiling engineering students was 349 at Rensselaer.

PURDUE UNIVERSITY.—The seniors and juniors of the Schools of Engineering made their Annual Trip of Inspection on Mar. 30, 31 and Apr. 1. The party of 170 students and 9 members of the Faculty visited Chicago for the purpose of inspecting various industrial establishments.

THE PENETRATION OF THE SIMPLON TUNNEL through the dividing wall between north and south headings was completed on the morning of April 2, 1905, when for the first time workmen passed through from one side to the other. The actual piercing of the dividing wall was accomplished five weeks before, on Feb. 24, 1905, as has already been noted in these columns. At that time the conditions did not permit a close examination of the junction of the heading. The end of the north heading, walled off nearly a year ago by a bulkhead several hundred feet back of the face, had filled with water under considerable pressure and at high temperature flowing from a large spring at the face. The north tunnel had at that time already progressed a considerable distance past the center of the tunnel, which is also the summit of the 0.7% grades in either half. A part of the north tunnel beyond the summit had been advanced on a down grade of only 0.1% instead of the proper grade, to facilitate drainage. When a blast in the south heading broke through one corner of the dividing wall, it afforded passage for the stored-up water and the continued flow of the spring. Considerable time was required for the tunnel walls to cool sufficiently to permit work at the junction to be continued. The day after the first penetration, a party of men connected with the work went into the tunnel to inspect the junction, but two were overcome by the heat and died shortly afterward. Symptoms of carbon monoxide poisoning were found on the bodies of both. Later, when the fresh air pipe had been extended, one of the principal engineers, with a small party, made as careful an inspection of the junction as was then possible, and concluded that the survey-lines of the two tunnels would prove to be very closely coincident, though apparently the longitudinal distance was a foot or two shorter than the surveyed length. Since that time the remaining part of the wall at the junction has been broken out, and on April 2 the bulkhead in the north tunnel was removed and parties from both ends of the tunnel met and exchanged greetings.

THE BISMARCK BRIDGE of the Northern Pacific Ry., carrying the railway over the Missouri River at Bismarck, N. D., is to have a new superstructure, weighing about twice as much as the old bridge, and figured for two 186-ton engines followed by a train load of 5,000 lbs. per ft. It is a single-track high-level bridge, with no draw span. The work of renewal is to be commenced as soon as the condition of the river will permit, and it is to be completed in one season without interruption of traffic. The piers will not undergo any alteration. The present bridge, which was built in 1883, was designed by the late George S. Morison. Mr. Ralph Modjeski, M. Am. Soc. C. E., of Chicago, is Consulting Engineer for the design and erection of the new superstructure.

MUNICIPAL OWNERSHIP OF STREET RAILWAYS has for some time been a prominent issue in Chicago municipal affairs and elections, and a tentative step towards this end has recently been taken. The franchises covering certain streets have expired, and the council committee on local transportation has authorized the Mayor to advertise at once for bids "for the construction and installation of a system of municipal street railways," to include these streets and certain others necessary for connecting up the lines into a workable system. Streets now covered by franchises which will expire within a year or two may also be included. Payment by the city will be made either in street railway certificates to be issued under the Mueller law, or in cash from the proceeds of the sale of such certificates by the city. Separate bids are to be submitted for the laying of tracks, the construction of pavements, and the car equipment. Bids must also specify whether the bidder proposes to operate the system under lease from the city, or to deliver it to the city to be operated by its own employees. Bids for operation are to state the percentage of gross receipts or the annual cash payment, and the term of years (not to exceed 20) which are to be provided by the lease. The fares under a lease are to be 5 cts. for passengers over 12 years, and 3 cts. for those between 7 and 12 years; children under 7 to be carried free. The bids are to be received until **July 1, 1905.**

A PECULIAR FIRE IN THE TUNNEL of the New York Rapid Transit Subway at Broadway and 168th St. did much damage on March 29. The subway at this point is in deep rock tunnel, and at 168th St. a shaft extends to the surface. A bulkhead across the tunnel near the shaft serves to control the flow of air. Just south of the bulkhead the subway is used for storing empty trains between runs. A switchman was proceeding northward to these storage tracks from the present terminal station at 157th St., and failed to notice a hand car standing on the track near the bulkhead. His train ran into the hand car and caused a short circuit between third-rail and running rails. The arcing started a fire, fed by some quantities of oil stored nearby and shaving and other timbers. A considerable amount of damage was done to the tunnel and the nearly completed station at 168th St. While a party of firemen was inspecting the tunnel after the fire had been extinguished, a part of the roof fell and killed one man.

AN EXPLOSION IN LEITER'S COAL MINE at Zeigler, Ill., April 3, entombed 50 miners. Thirty-seven bodies have thus far been recovered. The explosion is believed to have been due to the accumulation of gas on Sunday while the mine was not being worked. The shock of the explosion was felt 12 miles away. There is a strike at the mine and non-union men have been employed. This has led to the rumor that the explosion was due to dynamite used by the strikers. In view of the magnitude of the explosion, it is not probable that it was due to anything but gas. Among the dead is William Scott Atkinson, State Mine Examiner, who lost his life trying to reach the bodies of the men entombed.

A TRAIN TELEGRAPH SYSTEM, which provides for communication between enginemen and station agents, and includes an automatic signal in the engine cab to show when another train is in the block, has been invented by Mr. Edward McClintock, of the McClintock Mfg. Co., St. Paul, Minn. Two metallic conductors are to be laid, insulated to form block sections, and the engines are to be fitted with the necessary electrical apparatus. When a train enters a clear block the signal in the cab displays a white light; but in case of another train being in the block, or a rail broken, a switch open, a red light would be shown and a bell sounded. The station agent or operator would also be able to operate the signals on the engine.

A SELF-PROPELLING WRECKING CRANE is one of the latest modifications introduced in railway crane equipment, and its special feature is that while the self-propelling attachment makes the machine independent of a locomotive while working at a wreck or in loading and unloading cars, handling material, etc., in the yards, the attachment can be almost instantly thrown out of gear so as to allow of the machine being hauled rapidly over the road by a locomotive. Wrecking cranes have so far not been made self-propelling, for while the styles of propelling gear used on steam shovel would be applicable to the cranes they could not readily be thrown out of action when the machine is hastily required to be hauled at high speed to the scene of action. This new design is being introduced by the Bucyrus Co., of South Milwaukee, Wis., and is so designed that it in no way interferes with the other workings of the crane. An important point of this device is that all parts (except a clutch collar keyed to one of the axles) are mounted either on the car body or the revolving frame, so that when the clutch on the axle is disconnected all other parts are thrown out of gear and there is nothing to prevent the crane being transported at high speed. This clutch can be thrown in or out by a single movement of the operator. The propelling mechanism is designed to allow for all necessary swiveling of the trucks and deflection of the car body upon the springs, and the use of a central gear and planet pinion enables the revolving machinery to be swung through a complete circle while the propelling attachment is in gear. Most of the work of a wrecking crane (when not actually engaged at wrecks) is done in a railway yard, being used as a locomotive crane for loading and unloading cars, handling stock, etc.; and by being made self-propelling, the service of a switching engine and the necessary crew are dispensed with when engaged on work of this kind.

A WATER-TUBE BOILER EXPLODED in the municipal light and water plant at Jacksonville, Fla., on March 5, killing three men and wrecking the boiler house. The explosion is described in the April "Bulletin of the Fidelity & Casualty Co., as follows:

The explosion blew out the side wall of the boiler-room, leaving the roof to fall upon the unexploded boilers. The brick smokestack immediately behind the boiler was not damaged.

The exploded boiler was rated at about 200 HP. It contained 112 tubes, 4 ins. in diameter, and 16 ft. long. The tubes were set in cast-iron headers. There were four tubes in each header, and the headers were arranged in horizontal and vertical rows. There were seven rows of these headers in the width of the boiler, and the rows were four headers high, making 28 headers in all. Not a single one of these 28 headers was injured in the least, although some of them were hurled great distances. The steam and mud drums remained intact. Two other boilers in the same battery were but slightly injured. The plant at which the accident occurred is modern in every respect.

From the above account, it would appear that the explosion was really either a bursting of the tubes of the boiler or else the pulling off of the headers from the tubes. Both of these methods of failure are so rare that the accident is deserving of special mention.

ENGINEERING MATERIAL PRICES.

(These prices will appear in the first or second issue of each month.)

TRACK FASTENINGS—
Chicago—at mill—Angle bars, 1.40 to 1.50 cts.; spikes, 1.70 to 1.75 cts.; track bolts, 2.40 to 2.50 cts.

RAILS, STEEL—
New York—at mill—New standard sections, $28; light rails, $23 to $24.50; old iron, f. o. b. New York, $22 to $22.50; old steel, rerolling lengths, $16.50 to $17.50; old steel, short pieces, $16 to $17; relayers, $20 to $21.
Chicago—at mills—New, $28, standard sections; light rails, $24 to $27; old iron, $20 to $20.50; old steel, 4 ft. and over, $15.50 to $15.75; old steel, less than 4 ft., $15 to $15.25; heavy relayers, $22.50 to $23; heavy relayers for side tracks, $20 to $20.50.
Pittsburg—at mill—Standard sections, $28.

STRUCTURAL MATERIALS—
New York—at tidewater—Beams, channels, angles and zees, 1.74½ to 1.84½ cts.; tees, 1.79½ to 1.89½ cts.; bulbs, angles and deck beams, 1.84½ to 1.94½ cts.
Chicago—Beams and channels, 3 to 15-in., inclusive, and angles 3 to 6-in., ¼-in. and heavier, 1.70½ cts.; tees, 3-in. and over, 1.81½ cts.
Pittsburg—Beams and channels, up to 15-in., 1.60 cts.; over 15-in., 1.70 cts.; angles, 3 × 2 × ¼-in. thick up to 6 × 6-in., 1.60 cts.; angles, 8 × 8 and 7 × 3½ ins., 1.70 cts.; zees, 3-in. and larger, 1.60 cts.; tees, 3-in. and larger, 1.65 cts.

PLATES AND SHEETS—
New York—at tidewater—Sheared plates, carload lots, tank, 1.74½ to 1.84½ cts.; flange, 1.84½ to 1.94½ cts.; marine, 1.94½ to 2.04½ cts.; fire box, 1.94½ to 2.50 cts.
Pittsburg—Tank, ¼-in. thick 6¼ to 14-in. wide, 1.50 cts. at mill, Pittsburg; flange and boiler steel, 1.60 cts.; marine and ordinary fire box, 1.70 cts., at mill, Pittsburg; locomotive fire box, 2 cts.

MERCHANT STEEL—
Chicago—Machinery, smooth finished, 1.91½ cts.; tire, smooth finished, 1.86½ cts.; railway spring, 1.86½ cts.; crucible tool, 6½ to 8 cts.; special tool, 13 cts. and up.
Pittsburg—Open hearth spring steel, 2.25 to 2.50 cts.; tire steel, 1.65 to 1.75 cts.; smooth finished machinery steel, 1.75 to 1.85 cts.; tool steel, ordinary grades, 5¾ to 8 cts.

IRON—
Pig Iron:
New York—No. 1 X Foundry, $17.75 to $18.25; No. 2 X Foundry, $17.25 to $17.75; No. 2 Plain, $16.50 to $17; Gray Forge, Northern, $16 to $16.50; Southern No. 1 Foundry, $17.25 to $17.75.
Chicago—Lake Superior Charcoal, $18.50 to $19; Northern Coke Foundry, No. 1, $17.75 to $18; Northern Coke Foundry, No. 2, $17.25 to $17.50; Northern Coke Foundry, No. 3, $16.75 to $17; Northern Scotch, No. 1, $18 to $18.50; Ohio Strong Softeners, No. 1, $18.80 to $19.30; Ohio Strong Softeners, No. 2, $18.30 to $18.80; Jackson Co. and Ky. Silvery, 6% Silicon, $21.30; Jackson Co. and Ky. Silvery, 7% Silicon, $21.80; Jackson Co. and Ky. Silvery, 8% Silicon, $22.30; Jackson Co. and Ky. Silvery, 10% Silicon, $23.30; Southern Silvery, 4 to 6% Silicon, $18.65 to $19.65; Southern Coke, No. 1, $17.65 to $17.90; Southern Coke, No. 2, $17.15 to $17.40; Southern Coke, No. 3, $16.65 to $16.90; Southern Coke, No. 4, $16.40 to $16.65; Southern Coke, No. 1 Soft, $17.65 to $17.90; Southern Coke, No. 2 Soft, $17.15 to $17.40; Southern Gray Forge, $16.50 to $16.75; Southern Mottled and White, $15.90 to $16.15; Bulleable Bessemer, $17.50; Standard Bessemer, $18 to $18.50; Alabama Basic, $17.65; Virginia Basic, $17.65.
Pittsburg—Foundry iron, Northern, No. 2, $16.25 to $16.50; $16 at Valley; Northern forge, $15.15 to $15.25 at Valley furnace; $16 to $16.10 Pittsburg.
Cast-Iron Pipe:
New York—Carload lots, net tons, 6 to 10 ins., at tidewater, $26.50.
Chicago—4-in. water pipe, $29; 6-in. and heavier, $28, with $1 extra for gas pipe.

MISCELLANEOUS MATERIALS—
Asphaltum:
Ventura and other California asphalts, $20 to $21 per ton at New York; Trinidad refined, $25 to $30 per ton; Venezuela asphalt, $25 to $30 per ton; Bermuda asphalt, $25 to $30.
Cement:
Rosendale, in wood, $1; Portland, domestic, $1.70 to $1.80; Foreign brands, $2.25 to $2.50.
Copper:
Lake, 15.25 to 15.37½ cts.; electrolytic, 15.12½ to 15.25 cts.; casting, 14.87½ to 15 cts.
Lead:
New York, spot, 4.50 to 4.60 cts.
Spelter:
New York, spot, 6 cts.
Tin:
New York spot, 30.15 to 30.30 cts.

LUMBER—
New York, wholesale prices:
Piling—Spruce, ordinary cargoes, 6 to 7 cts.; oak, 14-in. butt, 40 to 50 ft., 19 cts.; 50 to 55 ft., 22 cts.; 55 to 60 ft., 23 cts.; 60 ft and up, 25 cts.; pine, 60 to 65 ft., $8.50; 70 to 75 ft., $10.50; 80 ft. and up, $16.
Railroad ties—Yellow pine, 6 × 9 ins. × 8 ft., 56 to 57 cts.; 6 × 8 ins. × 8 ft., 51 to 52 cts.; 7 × 9 ins. × 8 ft., 62 to 64 cts.; 7 × 8 ins. × 8½ ft., 58 to 60 cts.; 7 × 9 ins. × 8½ ft., 63 to 65 cts.

PERSONAL.

Mr. Ralph E. Shaner has been reelected Borough Engineer of Pottstown, Pa.

Mr. Alexis H. French, M. Am. Soc. C. E., has been reappointed Town Engineer of Brookline, Mass.

Mr. W. L. Thompson has been appointed Engineer for the Village and Township of Ridgewood, N. J.

Mr. David S. Rundlett has been appointed Superintendent of the water-works of Watertown, Mass., to succeed Mr. John H. Perkins.

Mr. Charles R. Allen, Jr., has been appointed City Engineer and Water Superintendent of Barre, Vt., the two offices having been combined.

Mr. William Starr has been elected City Engineer of Bridgeport, Conn., to succeed Mr. H. G. Schofield, who had held that position for the past 30 years.

Mr. A. L. Rogers, formerly with the Stirling Co., is now connected with the Platt Iron Works Co., of Dayton, O., with headquarters at 93 Liberty St., New York City.

Mr. Carl Ewald Grunsky, M. Am. Soc. C. E., formerly member Isthmian Canal Commission, has been appointed a Consulting Engineer to the U. S. Reclamation Service.

Mr. H. V. Wallace, who recently resigned the position of Chief Engineer of the Illinois Central R. R., is now General Manager of Thomas Phee & Co., contractors, of Chicago.

Mr. Henry W. Klare has resigned his position as Chief Engineer of the Virginia Bridge & Iron Co., Roanoke, Va., and is succeeded by Mr. A. Z. Drozdov, as was noted in our last week's issue.

Mr. Henry O. Peckham, Engineer of the Sewer Department of Wakefield, Mass., has been appointed Superintendent of Streets and Sewers of that town, the two offices having been united.

Mr. H. A. Comstock, Engineering Aid in the U. S. Reclamation Service, has been assigned to hydrographic work in South Dakota. He will report to Mr. Raymond F. Walter, Belle Fourche, S. Dak.

Mr. D. J. Brumley, hitherto Division Engineer of Construction of the Indianapolis Southern Ry., has been appointed Principal Assistant Engineer of the Illinois Central Ry., in charge of construction.

Mr. Jean Bart Balcomb, of 939 Golden Gate Ave., San Francisco, Cal., has been appointed Superintendent of Construction with the Nevada Power Mining & Milling Co., now installing a power plant on Bishop Creek, Cal.

Mr. H. A. Wheeler, M. Am. Inst. Min. Engrs., having completed his engagements in the Mining Department of the Louisiana Purchase Exposition, has opened an office as consulting mining engineer in the Roe Building, St. Louis, Mo.

Mr. John C. Cleghorn, of Iowa, has received an appointment as Engineering Aid in the U. S. Reclamation Service. He will report to S. B. Robbins, at Great Falls, Mont., where he will be engaged in work on the Sun River project.

Mr. John T. Keenan, of Colorado, has been appointed Assistant Engineer in the U. S. Reclamation Service. Mr. Keenan will engage in work on the Uncompahgre Valley project at Montrose, Colo., under the direction of Mr. I. W. McConnell.

Mr. John C. Avakian, of California, has received an appointment as Assistant Engineer in the U. S. Reclamation Service, and has been assigned to work in California. He will be under the directions of Supervising Engineer J. B. Lippincott, of Los Angeles.

Mr. Butler Smith has resigned as Chief Engineer of the Indianapolis & Ohio Valley Traction Co., owing to his other duties with the Vandalia-Pennsylvania Co., Mr. Smith, however, still retains his duties on the directorate of the first mentioned company.

Mr. Elver L. Shinhur, of Colorado, has received an appointment as Engineering Aid in the U. S. Reclamation Service, and ordered to report to I. W. McConnell at Montrose, Colo., where he will be engaged in connection with the Uncompahgre Valley project.

Mr. Dean Leroy Chilson has been appointed Superintendent of the Franklin Water Co., of Franklin, Mass., to succeed Mr. A. Burt Palmer. Mr. Chilson is a graduate of Tufts College and for some time has been engaged in the practice of civil engineering at Barberton, O.

Mr. C. A. Magill, for the past three years Deputy Street Commissioner of Lynn, Mass., has been appointed Superintendent of Streets of Woonsocket, R. I. Mr. Magill, who is a civil engineer, was formerly connected with the engineering firm of Thayer & Magill, of Westfield, Mass.

Mr. J. T. Norton, M. Am. Soc. C. E., has resigned the position of Secretary-Treasurer and Assistant Engineer of the Public Belt Railroad Commission of New Orleans, La., and will go to Central America, where he will be employed as Superintendent of Construction on the Guatemala R. R.

Mr. Frederick W. Harris, a civil engineer for some time in the employ of the Metropolitan Water and Sewerage Board of Massachusetts, at Clinton, Mass., has resigned his position with that board, and has accepted a position as one of the engineers on the construction of the filtration plant at Pittsburg, Pa.

Mr. W. A. Stadelman, for ten years General Eastern Agent of the Brown Hoisting Machine Co., has been appointed General Eastern Agent of the Wellman-Seaver-Morgan Co., Cleveland, O., with offices at 42 Broadway, New York City. Mr. Stadelman assumed the active duties of his new business on April 1.

Mr. Thomas H. Humphreys has been promoted from the position of Assistant Engineer to that of Engineer in the U. S. Reclamation Service, and has been assigned to work at Klamath Falls under Supervising Engineer J. B. Lippincott. Mr. Humphreys is a native of Idaho and was graduated from the Utah Agricultural College with the degree of B. S. in C. E.

Mr. José Prinelles, for the past five years Director General of Public Works of Cuba, has resigned that position and has entered the employ of the firm of C. Hempel, of Havana, importers of machinery and contractors for power and electric plants. The firm proposes also to enter the field of public work contracts. Mr. Duque Estrada, First Assistant to Mr. Prinelles, has also resigned, and has entered the employ of Snare & Triest Co., of New York, as Engineer for their Cuban works.

Mr. Lawrence Griffith, Assoc. M. Am. Soc. C. E., heretofore Engineer Maintenance of Way of the Grand Central Station and Harlem Line of the New York Central & Hudson River R. R., has resigned to become Vice-President of the Federal Railway Signal Co., with office at 150 Nassau St., New York. After April 30 the office will be at 60 Wall St., New York. Mr. Griffith, after leaving college, entered the service of the Baltimore & Ohio R. R. as apprentice in their shops at Mt. Clare, Baltimore, Md., leaving the B. & O. to go with the Pennsylvania R. R., where he was nine years connected with its Signal Department. He left the Pennsylvania to become Supervisor Grand Central Station, New York, afterward becoming Assistant Manager and Engineer Maintenance of Way.

The personnel of the new Isthmian Canal Commission has been announced, as follows: Mr. Theodore P. Shonts, President of the Clover Leaf R. R., Chairman and Member; Mr. Charles E. Magoon, of the Law Department of the War Department, Member and Governor of the canal zone; Mr. John F. Wallace, M. Am. Soc. C. E., now in charge of the engineering work in the canal zone, Member and Chief Engineer; Rear Admiral Mordecai T. Endicott, M. Am. Soc. C. E., Chief of Bureau Yards and Docks; Brigadier General Peter C. Hains, M. Am. Soc. C. E., United States Army, retired; Colonel Oswald H. Ernst, M. Am. Soc. C. E., Corps of Engineers, United States Army; Mr. Benjamin M. Harrod, M. Am. Soc. C. E., the only present member of the Commission to be reappointed. Professor William H. Burr, M. Am. Soc. C. E., and Mr. William Barclay Parsons, M. Am. Soc. C. E., present members of the Commission, will be appointed members of the consulting board of engineers. The first three named members of the Commission will form the Executive Committee, Mr. Shonts having the first department, which embraces the fiscal affairs of the Commission, purchase and delivery of materials, and transaction of the business of the Commission generally. The second department, placed in Judge Magoon's charge, is concerned with the government of the canal zone and its sanitation. The third department, which has been placed in charge of Mr. Wallace, embraces the engineering work of the canal. These three commissioners must live on the Isthmus.

Obituary.

Geo. A. Lederle, M. W. Soc. C. E., of the contracting firm of Christie & Lowe, Chicago, died March 25 at New Orleans, La.

Isaac L. Requa, formerly President of the Central Pacific R. R., died recently at San Francisco, Cal. He was born in Tarrytown, N. Y., 80 years ago.

Col. Frederick De Funiak, formerly Chief Engineer of the Louisville & Nashville R. R., died March 29 at his home in Louisville, Ky. Col. De Funiak was born in Rome, Italy, 65 years ago, and was a veteran of Garibaldi's army. He had been connected with the construction of railroads in many parts of the country.

James M. Seymour, head of the firm of Seymour & Whitlock, of Newark, N. J., manufacturers of machinery, died of apoplexy April 1 at his home in Newark. During the Civil War Mr. Seymour went to Spain to superintend the manufacture of gun machinery for the Spanish Government. He was for a time Master Mechanic on the Havana & Matanzas Railroad in Cuba and was chief engineer of a large sugar plantation there.

William F. Potter, who succeeded the late William H. Baldwin as President of the Long Island Ry. last January, died April 2 at his home in New York City of spinal meningitis. Mr. Potter was born in Utica, N. Y., in 1855, and entered the employ of the Pere Marquette R. R. in 1875 in a clerical capacity. He became General Superintendent of that road in 1896 and Vice-President and General Manager in 1904, leaving at the death of Mr. Baldwin to become President of the Long Island Ry.

George A. Marr, M. Am. Soc. C. E., U. S. Assistant Engineer and Superintendent of the Portage Lake Ship Canals, died March 24 at Chicago, Ill. Mr. Marr was born at Gravesend, Ontario, in 1837, and was graduated from the University of Michigan in 1862, receiving the degree of C. E. from the same institution in 1863, and the degree of M. S. in 1867. Mr. Marr was first employed by the U. S. Lake Survey in 1861-62, in some minor capacity, probably as recorder. From 1863 to 1877 he was Assistant Engineer; afterwards he was Assistant Engineer on the U. S. surveys and improvements of the Missouri River and the upper portions of the Mississippi R... From 1891 to the date of his death he was Superintendent and Assistant Engineer of the Portage Lake Canals, Houghton, Mich., under Major Chas. L. Potter, Corps Engineers. In all he was engaged 44 years on Government engineering work, which is believed to be a longer period than that of any other person on the Great Lakes. At the time of his death he was returning from a trip to Mexico, which he had taken for his health.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN ELECTROCHEMICAL SOCIETY.
April 25 to 27. Annual meeting at Boston and Cambridge, Mass. Secy., S. S. Sadtler, 39 South 10th St., Philadelphia, Pa.

NATIONAL MUNICIPAL LEAGUE.
April 25 to 28. Annual convention at New York, N. Y. Secy., C. R. Woodruff, Philadelphia, Pa.

INTERNATIONAL RAILWAY CONGRESS.
May 3 to 15, 1905, at Washington, D. C. Secy. of American Committee, W. F. Allen, 24 Park Place, New York.

AMERICAN WATER-WORKS ASSOCIATION.
May 8 to 12, 1905. Annual meeting at West Baden, Ind. Secy., J. M. Diven, Charleston, S. C.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
May 16, 1905. Annual meeting at New York, N. Y.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
June 6, 7, 8, 9, 1905. Annual spring convention at Scranton, Pa. Secy., F. R. Hutton, 12 West 31st St., New York, N. Y.

AMERICAN FOUNDRYMEN'S ASSOCIATION.
June 6 to 9, 1905. Annual convention in New York. Secy., Richard Moldenke, Watching, N. J.

MASTER CAR BUILDERS' ASSOCIATION.
AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 14-21, 1905. Annual meeting at Manhattan Beach, N. Y. Secy., J. W. Taylor, The Rookery, Chicago, Ill.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 19 to 23, 1905. Annual convention at Asheville, N. C. Secy., R. W. Pope, 95 Liberty St., New York, N. Y.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 20 to 23. Annual convention at Cleveland, Ohio. Secy., Charles Warren Hunt, 220 West 57th St., New York, N. Y.

LEAGUE OF AMERICAN MUNICIPALITIES.
August 23 to 25. Annual meeting at Toledo, O. Secy., J. McVicar, Des Moines, Ia.

BROOKLYN ENGINEERS' CLUB.—The next regular meeting of the club will be held at the club rooms, 197 Montague St., Brooklyn, N. Y., on the evening of April 13, 1905. Mr. F. C. Schmitz will read a paper, entitled "The Fireproofing of Framed Structures." Secy., Jos. Strachan.

AMERICAN ELECTROCHEMICAL SOCIETY.—The provisional program for the Boston annual meeting, April 25 to 27, has already been noted in this column. A fuller list of the papers to be read has just been issued, as follows:

"The Heat of Solution of Aluminum Bromide in Ethyl Bromide," by Prof. H. E. Patten; "The Interdependence of Atomic Weights and Electrochemical Equivalents," by Prof. A. Reuterdahl; "An Optical Method for Observing Diffusion in an Electrolyte," by C. Hambuechen; "The Microstructure of Silicon and Silicon Alloys," by A. B. Albro; "Specific Inductive Capacities," by Prof. L. Kahlenberg; "The Rotating Diaphragm," by Prof. W. D. Bancroft; "Notes on Economic Temperatures of Copper Refining Solutions," by Prof. C. F. Burgess; "Electrolytic Precipitation of Chromium," by Prof. H. R. Carveth; "Conduction in Electrolytes," by Prof. J. W. Richards; "The Adherence of Nickel to Nickel," by R. C. Snowdon; "The Electrodeposition of Silver," by R. C. Snowdon; "Treating Low-grade Ore and Tailings by Electrolysis," by E. Fahrig; "Some Experiments with the Reduction of Titaniferous Ores into Steel and Titanate of Iron," "Experiments on the Reduction of Different Oxides of Lead by Electric Current," and "Experiments with the Electrodeposition of Metals on Aluminum," by A. Lodyguine; "Billitzer's Method of Determining Absolute Potentials," by H. M. Goodwin; "The Utilization of Blast-Furnace Gases in Connection with Electric Smelting," by A. J. Rossi; "A Low-Voltage Standard Cell," by Prof. G. A. Hulett; "A Diaphragm Cell for Electrolysis of Brine," by C. P. Townsend; "Colloids," and "Electric Arcs," by W. R. Whitney; "The Mercury Arc," by E. Weintraub; "Reversible and Irreversible Polarization," by Prof. W. S. Franklin; "An Electric Switch," by W. S. Horry; "The Electrostatic Method for Separating and Concentrating Ores," by Prof. L. I. Blake; "The Aluminum Electrolytic Condenser," by C. J. Zimmerman; "Metallic Thorium," by Prof. C. Baskerville and F. Zerban.

The meeting will open with a session in Lowell Bldg., Massachusetts Institute of Technology, at 9.30 a. m., Tuesday, April 25. The presidential address is to be delivered the evening of the same day. Another session will be held at Pierce Hall, Harvard University, on Wednesday morning, and two sessions, morning and afternoon, Thursday, at the same place as the first session. Excursions will be arranged to the General Electric Co.'s shops at Lynn, Mass., to the New England Gas & Coke Co.'s plant at Everett, etc. The local committee will provide entertainment for visiting ladies. Prof. H. P. Talbot, Massachusetts Institute of Technology, is secretary of the local committee.